Winter 1972

Data Management for a Police Command/Control Simulation Study

Gerald Louis LoCasale
University of Central Florida

DATA MANAGEMENT FOR A POLICE COMMAND/CONTROL SIMULATION STUDY

by

Gerald Louis LoCasale
B.S.E., University of South Florida, 1970

Thesis

Submitted in partial fulfillment of the requirements
for the degree of Master of Science in Engineering
in the Graduate Studies Program of
Florida Technological University, 1972

Orlando, Florida

PREFACE

The primary purpose of this thesis is to aid the Orlando Police Department locate areas of improvement with the effect of reducing the total response time of the Command/Control Center through the application of basic industrial engineering techniques.

This work is presented in three major chapters. The first is concerned with the definition of the present operation of the Center, the total scope of each separate function within the Center and the interactions with the general public and other public safety departments. The second chapter develops the studies which provide the input values for the simulation model and the analysis of these parameters through statistical testing procedures. The final chapter states the interpretations of the statistical values and indicates the areas where industrial engineering techniques could best be applied to reduce the total response time of the Command/Control Center.

This work was supported by a grant from the Governor's Council on Criminal Justice to the Orlando Police Department.

The author wishes to express deep appreciation for the expert guidance given by Dr. Robert D. Doering, Dr. Klaus W. Lindenberg, Dr. Miguel F. Zaldivar and Prof. Chris S. Bauer. To the secretarial staff of the Industrial Engineering Department of Florida Technological University and to the uniformed and civilian personnel of the Orlando

Police Department the author wishes to express the deepest thanks for their tolerance and professionalism without which this thesis could not have been completed.

TABLE OF CONTENTS

CHAPTER I

OPERATIONAL DESCRIPTION

1.1 Introduction

All police departments utilize some system by which they direct and control their field forces in a dynamic response environment. This system of Command and Control must have the inherent capability of rapid and complete information assembly, decision making and execution which will assure rapid response to the threat situation and minimize the danger to both citizen and police officer.

The immediate objective of this chapter is to define the present operation of the Command/Control Center so that a statistical data base may be designed to describe the actual operation. Since the Command/Control Center function uses three distinct areas of responsibility (Complaint Desk, Radio Dispatch and Teletype), each area and their interactions will be described.

1.2 Operational Mode

The Command/Control Center coordinates all the uniformed field assignments and the dissemination of information to and from the field units, the general public, the police department and the public safety departments of neighboring communities. To discharge its mission the Command/Control Center must interface with the general public, all police functions within the City of Orlando and other law enforcement and Public Safety Agencies. Each interface may require a different

response from the Center. For example, the actions may include giving watch personnel assignments, calling an ambulance, answering questions on laws, relaying information and dispatching police units. Each response may involve one or more components of the Command/Control System which must work in unison to perform the function. Although procedures exist, they clearly cannot cover all situations and required actions. It is possible to categorize the response by type of operational mode required. Accordingly, four operations modes are defined and have been used to analyze the Command/Control Operations. The result is a functional analysis which describes the actions of components in the system given a specific operational mode.

The first operational mode is termed Routine. This mode includes normal daily activities which do not result in a permanent case or file number being required. The Complaint Desk action may include answering an information request of an incoming call. The routine operations of the Teletype Operator would be an information query and receive a negative response. The Radio Operator's routine operational mode requires monitoring the assigned channels and patrol unit status.

The Incident Mode does not differ significantly from the Routine with the exception that a police file is created. In the Incident Mode a crime has been committed or a suspect arrested.

Whenever an in-progress crime is reported or a "unit-needs-assistance" call is received or any personal injury is reported, all sections of the Command/Control and field forces assume the Emergency Operational Mode. This mode may be initiated by the Command/Control

Center or by a field unit on patrol, a citizen may require an ambulance or a routine identification check may result in hot pursuit when the on-scene unit would require assistance. The Emergency Mode requires close interaction between the Command/Control Center and the field force.

The final mode requires no interaction between the sections of the Command/Control System. The Internal Mode is comprised of operations or tasks which are unique to the subsystem involved.

For each mode a detailed functional flow diagram relating the major subsystem activities is included in the Appendix for reference. The true complexity of the operation can be visualized when it is realized that at least 24 uniformed patrol units may be in the field and each unit may be in any mode. The Command/Control System mode depends upon the type of call being processed, the type of call being answered on the telephone, the type of teletype information requested and the type of radio traffic existing at any given time.

1.3 Complaint Desk Operation

The general public calls the Police Department when it needs emergency aid, wishes to report a crime or suspicious activity or simply desires information. In Orlando the Police Department "emergency" number is on the front inside cover of all telephone directories and on every "marked" patrol unit. Dialing this number will automatically place the caller in contact with a Complaint Officer at the Command/Control Center. Although the caller may never see this officer, his very life could depend on the officer's decisions and actions. To this

citizen the Complaint Officer is the Police Department; how he conducts himself over the phone will be equated with the actions of all uniformed police.

Until it is determined otherwise, calls to the Complaint Officer's desk must be considered an emergency. The call must be answered, information obtained, all requisite forms completed and a patrol unit dispatched, if required, within the shortest possible time. How the information is obtained is based on training and experience, but the same general information is required of every incoming call before any decisions may be made.

The Complaint Officer must determine:

1. Name and location and telephone number of the caller.

2. Location of the incident.

3. Nature of the call, that is, to report a crime or disturbance, to report an accident or to request information.

4. Names of involved persons.

5. Whether the call required immediate or emergency assistance such as an ambulance.

With this information the Complaint Officer determines if the location of the need is within the Orlando Police Department jurisdiction, whether a patrol unit should be sent, whether an ambulance or other assistance should be dispatched, and if a case number for a permanent police record is required. These decisions may have to be made for all incoming calls, although the order in which they are made vary by Complaint Officer.

If a call is answered by the Complaint Desk for which the Orlando Police Department has no jurisdiction, the Complaint Officer may either record all the information and then relay it to the proper agency, or the Complaint Officer may interrupt and give the caller the telephone number of the appropriate agency if it is a non-emergency call.

If a call does require a police unit, the Complaint Officer will complete either a 602-09 or 602-03 form (shown in the Appendix). These forms summarize the information pertinent to the call and enable the Complaint Officer to indicate the patrol district and patrol unit to be assigned, if available. The 602-09 form is completed when it is anticipated that a police record will not be required. The 602-03, however, has a sequenced record number in the top right corner and is completed when a police report file will be created on the incident. When either form is used, the time of day and date is electronically stamped on the card before it is deposited on a conveyor belt which transports it to the Radio Operator. Figure 1 shows the operational flow chart of the decision process and information gathering process the Complaint Officer follows for each telephone call.

All "messages" or "local-look-outs" must be approved by the Complaint Officer. This is done to minimize the broadcasting of repetitive information to the field units. He is also responsible for informing owners of businesses where burglaries have been attempted and notifying the other law enforcement agencies of the incident which could effect communities outside of Orlando. He is the advisor as to which units to dispatch and the source of information to the field unit relative to

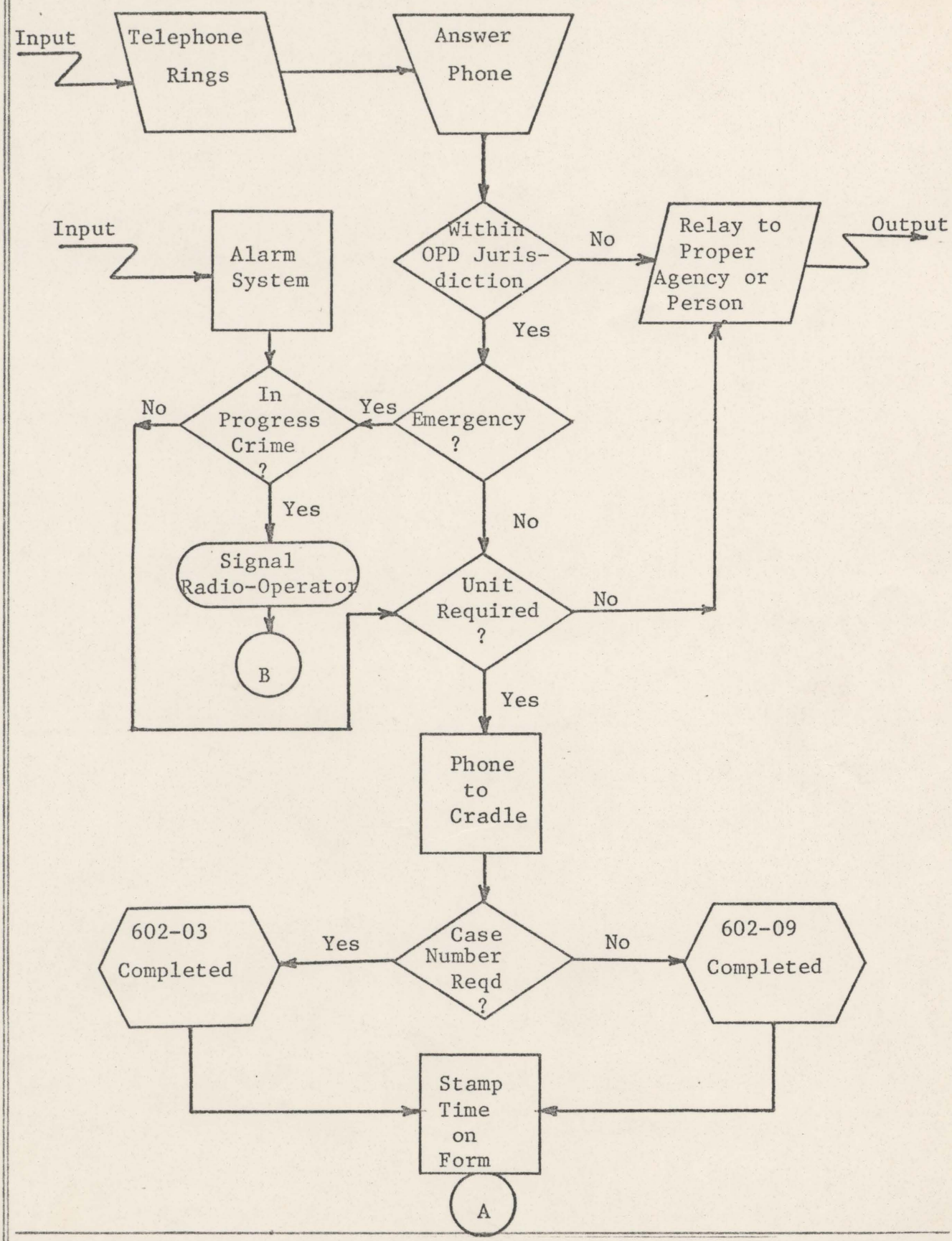


Fig. 1.--Operational Complaint Desk Flow Chart

pertinent information on the incident, such as the general mood of the caller.

1.4 Radio and Teletype Operation

The Radio Operator relays dispatch assignments and information to the department patrol units and receives requests for clarification and/or additional information by radio. Additionally, this position can communicate by radio and direct telephone lines with other regional law enforcement agencies and fire and ambulance services.

Inputs to the Radio-Operator may originate from four sources:

1. A form completed by the Complaint Officer.
2. Monitoring the city-wide alert channel.
3. A "message" from the Teletype Operator through the Complaint Officer.
4. Field force request via radio.

The actions by the Radio Operator keyed to the respective input sources are shown in Figures 2 and 3. These operational steps are designed to assign a patrol unit, investigative vice unit, K-9 or "motor" unit to the area of need as quickly as possible. To facilitate determination of the nearest available patrol unit, a visual display of status information is used which indicates all units assigned on the particular watch together with their primary assigned district and their immediate status. This display system is called the Force Status Board.

When a card is received via the conveyor belt, the Radio Operator checks the Force Status Board and calls the designated unit if available. The time at which the unit is called and the time when the

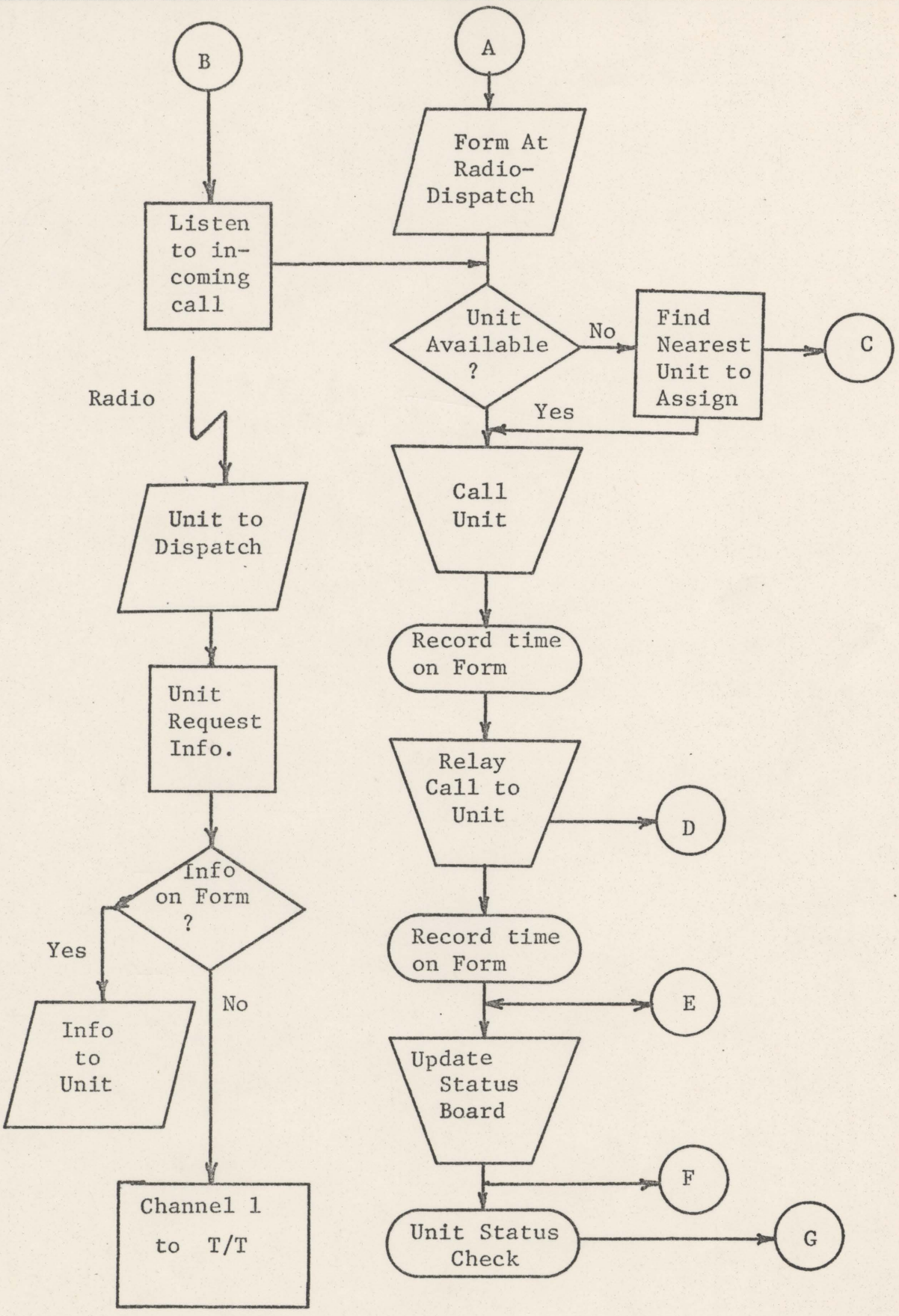


Fig. 2.--Operational Radio-Dispatch Flow Chart

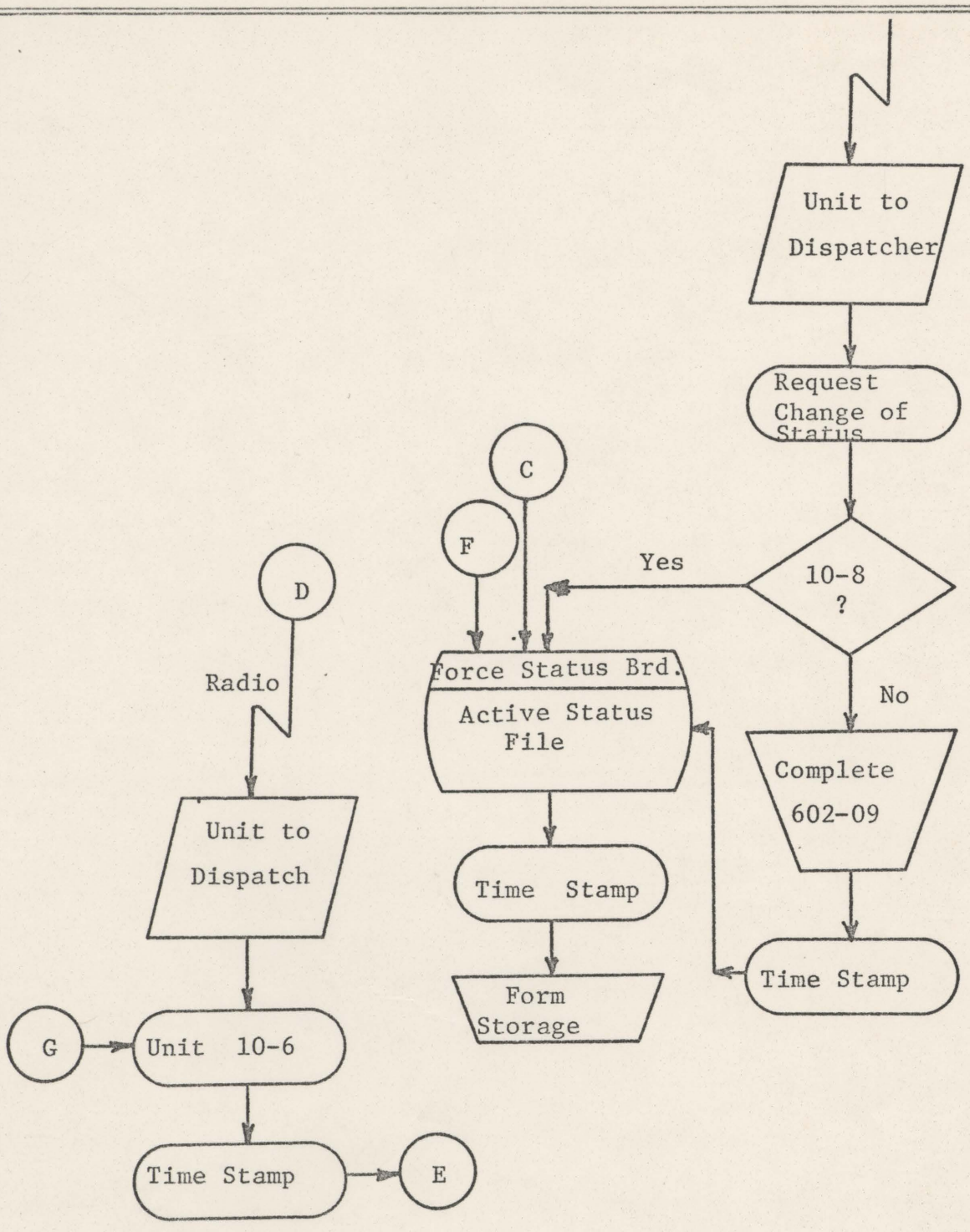


Fig. 3.--Operational Radio-Dispatch Flow Chart

Radio Operator has completed transmitting the information to the unit are recorded on the form by time stamp. This card is then filed in the numbered slot corresponding to the number of the unit dispatched. This action causes a light keyed to the unit on the Force Status Board to change from green, which signifies the unit is available, to red, which signifies the unit is on a call and not available.

When the unit arrives at the incident site it calls the Radio Operator and reports 10-6 or "at the scene". The Radio Operator then removes the form from the status file slot, stamps the time reported 10-6 and replaces the form in the status file. At the discretion of the Radio Operator, a status check of that unit may be instituted by calling the unit and determining if it requires assistance. The times are recorded on the reverse side of the form. This check is routine when an "in-progress" crime call is answered on when an unusually long time has passed before the unit has cleared the scene. When the unit has completed the assignment, it reports code 10-8 to the Radio Operator; this time is also stamped. The Radio Operator is also notified when a unit requests a change of status which may be due to mechanical difficulty or investigation of observed suspicious activity for example. When this request is made, a form with the unit number and location is stamped and put in the status file and the corresponding light for that unit shows red on the Force Status Board.

Input to the Teletype (T/T) Operator may occur from a field unit, the National Crime Information Center (NCIC) or the Florida Crime Information Center (FCIC). When a field unit requests information, it

calls on a channel other than the dispatch channels directly to the T/T Operator. If the T/T Operator has the requested information on file, the response is immediate. If the information is not on file, a query to NCIC and FCIC is made and the results transmitted via radio to the unit by the T/T Operator.

NCIC and FCIC also broadcast to all law enforcement agencies information on stolen items, persons wanted and other pertinent information. The T/T Operator receives this information, updates the appropriate files and relays the pertinent information to the Complaint Desk. Figure 4 shows the operational flow chart of the teletype operation.

1.5 Uniformed Patrol Force Operation

The police function can only be served by a concerted team effort between the unit on patrol and the Command/Control Center. At the first level of authority, the Watch Commander's primary responsibility is to ensure that a team effort exists between his uniformed field units and the Command/Control Center. The Watch Commander has responsibility for all patrol units during his watch, monitors all the channels of communication and may redirect the assignment of units by the Command/Control Center.

The second level is the Sector Commander. As a front line supervisor, He is assigned a quadrant of the City which contains several districts and is responsible for the supervision and training of the patrol units in his sector. In the field the Sector Commander monitors all units assignments in his sector and may modify these as his experience and knowledge of field conditions indicate. He also functions as a patrol unit which is available for assignment by the Command/Control

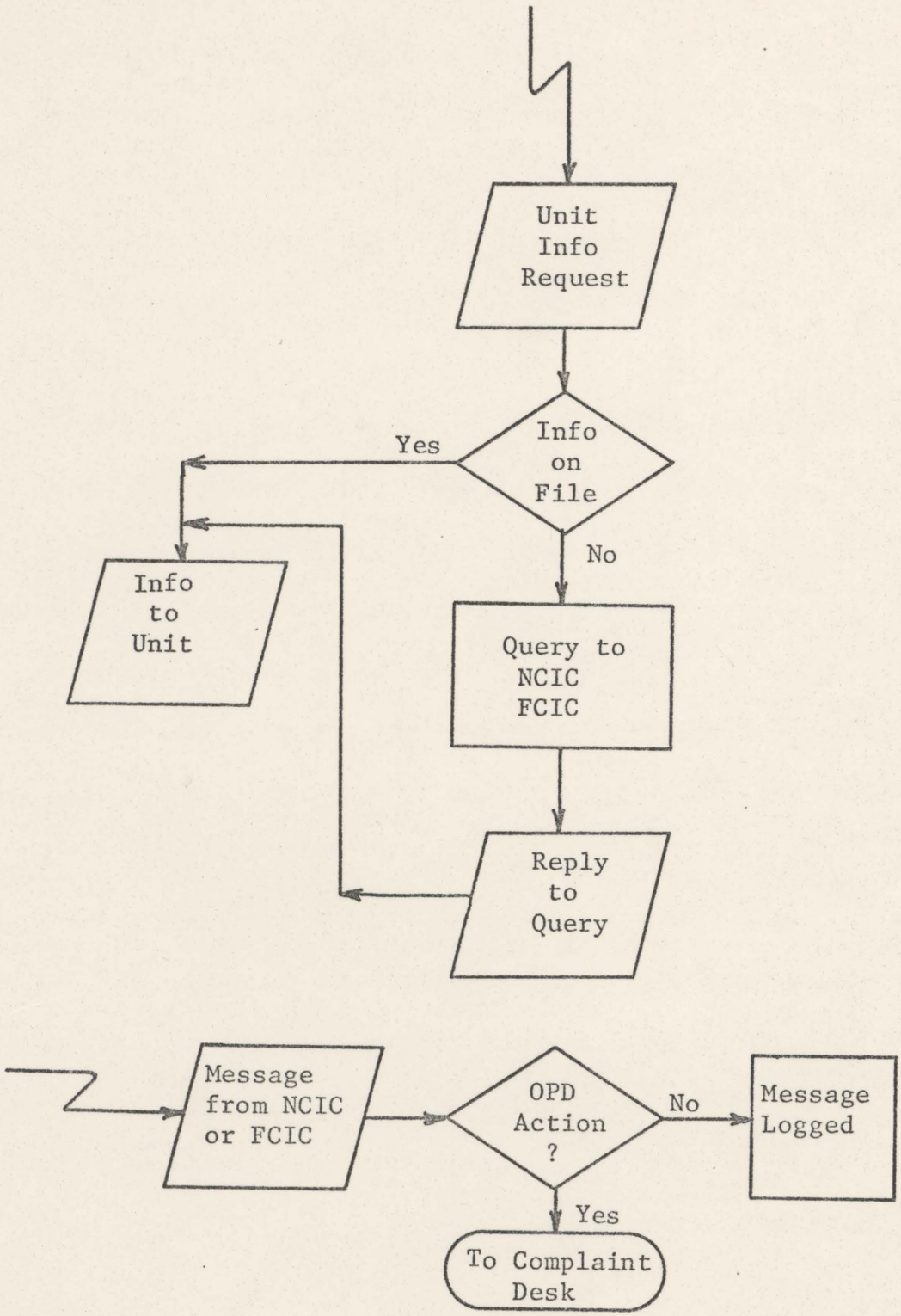


Fig. 4.--Operational Teletype Flow Chart

Center. This is not common but does occur when a serious incident is reported and no other units are available.

The Sector Commander will assist any patrol unit in his sector as the type of call indicates. This backup may consist of simply patroling the district until the unit on assignment is again available, or it may mean direct supervision to train a patrol unit in techniques of investigation, rules of evidence or other pertinent police procedures. His responsibilities also include administrative duties such as inspection, scheduling extra duty and vacations. He reviews the crime statistics and training progress on a periodic basis with the Watch Commander and investigates reported misconduct.

The third level of responsibility is the Patrol Unit. After the watch briefing meeting, the unit proceeds to the assigned district and relieves the previous unit. While on patrol the unit will receive and acknowledge assignment from the Command/Control Center and the Sector and Watch Commanders. After each assignment the unit resumes patrol activities. If, while on patrol, the unit stops to investigate suspicious activity, it must inform the Command/Control Center of its location and the type of activity. During this investigation the unit may require information as to stolen goods or warrants. This information is available through the teletype operation of the Command/Control Center.

Regardless of the level of authority and responsibility of the patrol unit, a concise flow of information to and from the Command/Control Center is essential for the peak effectiveness of the patrol unit.

1.6 Physical Layout and Equipment

The Complaint Officer, Radio-Dispatch Operator and Teletype Operator require specific support equipment to discharge their functions. For the Complaint Officer to receive telephone inputs, gather information, make decisions and complete the necessary forms, a quiet, well-lighted area must be provided. Since the Complaint Officer must be aware of the available patrol units, he must be able to observe the board in the radio room.

The communications equipment at the Complaint Desk station (see Figure 5) consists of a multiextension phone for each desk and an electronic security alarm system. Each phone has the maximum capability of 29 direct extensions or lines. At the present time not all lines are assigned; however, eight direct lines including two to fire, one to Florida Highway Patrol, one to Orange County Sheriff's Department, one to the Electronic Securities Company, two to ambulance companies in the area and one to a towing service are active. Six emergency number direct lines are in service. When the caller dials 843-5000 the call will automatically be routed to a line which is free. Each phone is also equipped for intercom communication with the two Radio-Dispatch stations, the Information Desk and with each of the other Complaint Desks. A Wells-Fargo type signal system is mounted on the South wall of the Complaint Desks room. This is a direct to station alarm system with 24 locations presently connected. It is actuated by company alarm circuits which automatically actuate a panel at Orlando Police Department.

A multichannel, multideck tape recorder is also installed in the Complaint Desk room. This provides a continous record of all telephone

inputs and outputs at the Command/Control Center and the Information Desk as well as all radio transmissions.

The Radio-Dispatch work station is the coordination point for all incoming and outgoing communications between the Command/Control Center and the field forces and should be quiet and in a low traffic area. It is manned by two operators who share the workload on an East/West division of the City. Two control consoles are provided and each is a duplicate of the other to provide an operational redundancy capability.

Auxiliary equipment (see Figure 5) includes Force Status Board and Active Complaint Status File. The interface equipment consists of a Complaint Card Conveyor to move assignment cards between the Complaint Desk and Radio-Dispatch work station and the radio and telephone communications network.

The radio communication controls are directly in front of the operator since this is the most frequently used portion of the equipment. The console is equipped to monitor the four Orlando Police Department channels as well as Orange County Sheriff's Department (O.C.S.D.) and Florida Highway Patrol (F.H.P.) transmissions and other selected local police agencies. The operator can selectively transmit and receive on the four UHF channels or on all frequencies at once in an emergency. Radio communication is also provided to the local police agency network. A headset microphone is normally used for transmission but a console monitored microphone can also be used. The console also has two telephones, one for emergency incoming calls and the other for direct line communications similar to the Complaint Desk telephones. The emergency phone is used only when activated by the Complaint Desk personnel.

Equipment List

1. Telephone
2. Electronic Security Alarm
3. Tape Recording Equip.
4. Teletype
5. Video Display
6. Single channel radio
7. Time stamp
8. Typewriter
9. "PREP" Radio
10. Emergency Telephone
11. Force Status Board

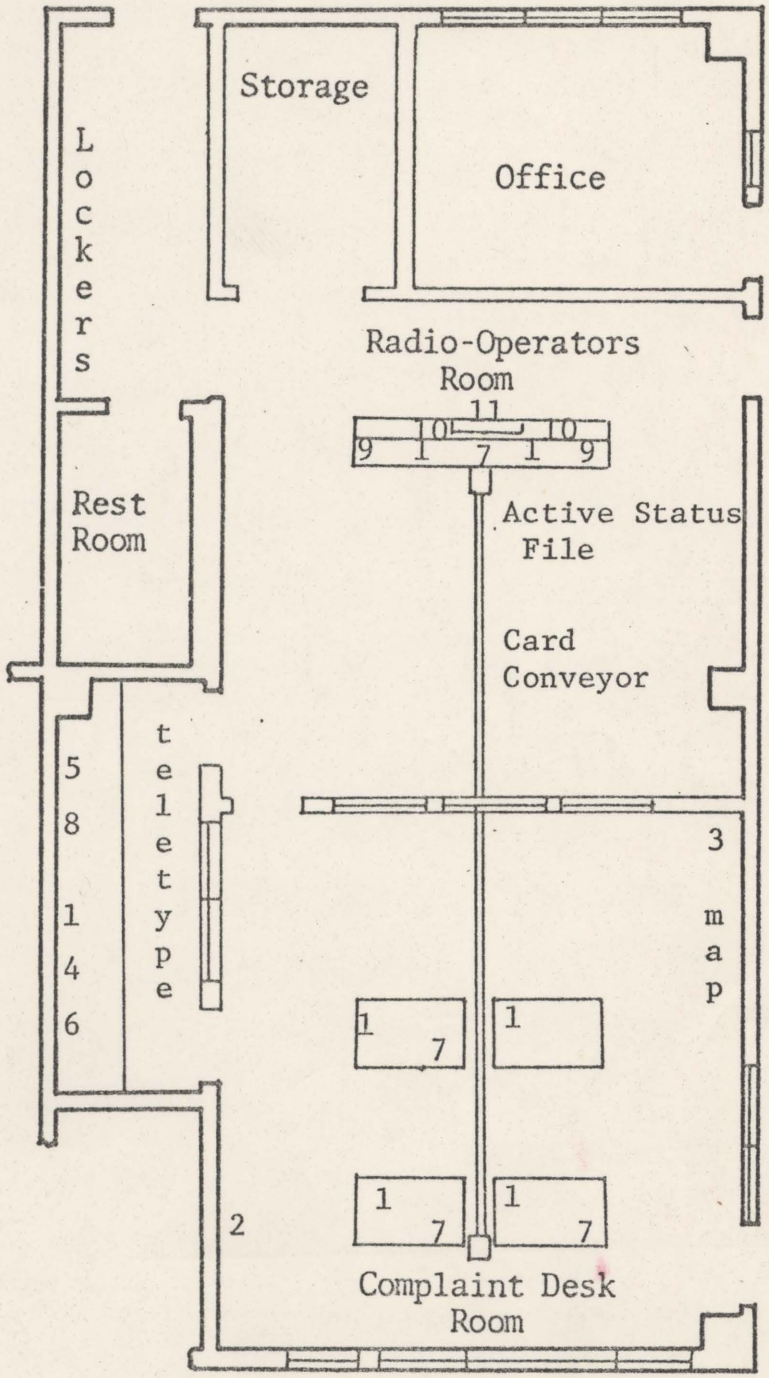


Fig. 5.--Showing Major Equipment Locations for each specialized task of Command Control.

The Radio Operator can either talk and receive with the handset or switch to a speaker position for receiving. The console also contains 12 push to alert switches which are used to page selected command officer personnel and high-ranking city officials.

The Force Status Board is positioned above and between the Radio Operator position. The Board contains a back illuminated map of the City with each patrol district outlined and identified. To identify each patrol unit the Board has two small lights, one red and one green, located within the district. To each side of the map there are groups of numbers corresponding to vice, detective, K-9, motorcycle and other special Police units which can be illuminated to indicate the unit is on duty and its status. The Board thus provides the status of every Police unit on duty by either a red or green light. All units on the Force Status Board are equipped with a PREP (Personal Radio Equipped Police) radio.

Connected with the Force Status Board is the Active Complaint Status File. This File is designed for the temporary storage of computer size assignment cards. The Status File is wired electrically to the Force Status Board so that when a card is placed in a numbered slot in the File the corresponding number on the Force Status Board changes from green, which indicates availability, to red, which indicates unavailability for assignment. At the beginning of each shift the Radio Operator verifies which special units are on duty and turns the corresponding light on the Status Board to green. Then, as assignments are made and completed, the Status File and Force Status Board indicate the status of all on duty units at any given time.

Seated at the Control Console each Radio Operator can communicate with any on-duty field unit using the PREP system, know the status of any unit, communicate by direct lines to other local law enforcement agencies, fire and ambulance, as well as communicate to the Complaint Desk via the intercom. The Control Console with its components is the heart of the Command and Control System Communications.

The teletype room is a high noise area. The teletype equipment is similar to a manual typewriter in noise level and must be insulated to contain the sound since the teletype room is adjacent to both the Complaint area and Radio Room.

The teletype equipment consists of one I.B.M. 2740 teletype machine which is connected directly to the NCIC and FCIC networks. One R.C.A. 70-752 Video display is connected to the Orange County Criminal Control System and is used to store and retrieve information from a computer on a County-wide basis. Two single extension telephones and a single channel radio complete the physical communications equipment at the Teletype Station. Support equipment includes a time stamp, Line-O-Dex file system for local warrants and a typewriter.

1.7 Summary

A police operations system includes specialized personnel and equipment whose activities must be planned, organized, directed and controlled to protect lives and property of the citizenry most effectively.

A key element in this operation is the Command/Control Communications Center. It provides a contact point between the inside world and the field forces, integrates the sources of information and has functional authority to direct and coordinate the field activities. Input to the Center can be initiated by the public via telephone, other law enforcement or public service agencies via telephone, radio or teletype and field units via radio or telephone. Typically an input to the system requires a data screening and analysis at the Complaint Desk Station, information dissemination at the Radio and Teletype Stations and information retrieval at the Teletype Station.

Staffing the Command/Control Center for continuous operation requires personnel skilled in these three work areas. An average watch manning includes a Supervisor, two Complaint Desk Officers, one Teletype Operator and two Radio Operators. Personnel are trained in the functions of each work station so that they can relieve each other as required.

The field patrol units are organized under a Watch Commander with four Sector Commanders supervising the Patrol Units in their sector. Each patrol unit has an assigned area or district in which they cruise and respond to calls. A patrol unit receives and responds to a dispatch order from the Communications Center. All assignments are monitored by the Sector Commander and other patrol units, and the Sector Commander may modify the dispatch order based on his knowledge of the field situation.

Operation of the system requires special communication equipment. All voice communications via radio and teletype are recorded on a continuous time synchronized tape. Department radio communications are via four channel UHF equipment which is designed as a PREP (Personal Radio Equipped Police) system. This permits two-way officer to officer or officer to headquarters communications. Several VHF channels are also available for vice and investigation communication as required and one channel for intercity police transmissions. The teletype system is tied to both FCIC and NCIC. The Complaint Desk and Radio Operator stations are connected by intercoms and have multiextension phones for incoming calls and direct lines to F.H.P., O.C.S.D., Electric Securities, Fire Departments and ambulance services. A Force Status Board located in the Radio Room is visible at the other stations and maintains the status of all patrol and detective units on watch.

CHAPTER II

STATISTICAL DESCRIPTION

2.1 Basic Data Collection Methodology

In order to simulate the Command/Control System the input, output and intermediate operational steps must not only be defined, they must be described in quantitative time elements. Two approaches were used to obtain the requisite data - random sampling of the operation as they occurred and historical data, where available. In both instances, the data was analyzed statistically to determine its validity at a confidence level.

Four major studies were required to generate the data for the simulation model. Initially a study was conducted to supply information on the total telephone activity of the system from the general public, from within Orlando police department, from other police and public safety agencies and from all calls originated by the Command/Control Center personnel. In this case the sample consisted of a continuous three month period in the Spring of 1972 during which 74,137 calls were recorded. These were entered in the "Command/Control Telephone Frequence Count Study" form by a stroke count in the appropriate columns (see Figure 6). Note that all calls during the sample periods were recorded. This required monitoring all telephone activity at the

JANUARY

COMMAND/CONTROL TELEPHONE FREQUENCY COUNT

DATE 5/20/72
SHIFT 1 (2) 3

FROM PUBLIC			O.P.D. DEPT. CALLS			CALLS FROM OTHER AGENCIES			CALLS TO OTHER AGENCIES		
TOTAL	602-03	602-09	TOTAL	602-03	602-09	TOTAL	602-03	602-09	TOTAL	602-03	602-09
11	11	11	11	1	11	11	11	11	11		

COMMAND/CONTROL TIME STUDY SHEET

Name: Tom
DATE 6/27/72
SHIFT 1 (2) 3

TIME OF DAY 1ST RING	PHONE TO EAR	PHONE TO CRADLE	LAST TIME STAMP	CARD AT RADIO-OPERATOR	CALL UNIT	PUNCH 10-51	PUNCH 10-6	CALL UNIT	UNIT REPLY	PUNCH 10-8	OFFENSE	FORMS: NONE	FORMS: 602-09	FORMS: 602-03	CENSUS TRACT	COMMENTS
0915	.03	.40	.44	1.77	3.21	3.46	7.40	9.03	9.15	15.29	TRAFFC			✓		
0924	.03	.42	.55	.66	4.06	4.13	4.31	—	—	5.02	10-45		✓			
0931	.04	.57	.71	1.46	1.62	1.71	1.82	—	—	3.03	10-45		✓			
0935	.06	1.28										✓				INFO
0939	.04	1.19	1.24									✓				C/D CHANGED MIND NO CARD SENT
0942	.06	.28										✓				TRANSFERED TO O.C.S.O.
0945	.04	.87	2.62	2.82	3.07	3.50	6.93			(8.00)				✓		79507
0955	.05	.18										✓				INFO
1000	.04	.23										✓				INFO
1051	.04	.25	.31	1.00	1.14	1.25	3.02			(14.00)	SHOP 390			✓		79533

Fig. 6.--Showing actual completed forms for the Telephone Frequency Count (top) and the System Time Study (bottom).

Complaint Desk and the Radio Dispatch work stations. This study formed the basis for all other studies because it included the entire telephone activity of the Command/Control Center.

The telephone input was further described by an "Inbound Telephone Rate Study." The purpose of this study was to determine the rate at which calls were received at the Complaint Desk as a function of the time of day. This data was used to form a histogram showing the lapsed time between inbound calls. The sampling procedure utilized a random selection of the day of week and a census of all inbound calls for that chosen day.

These two studies describe the input call profile to the Command/Control Center. They employ both random sampling and a total or census counting to gather the numbers necessary for the statistical analysis. The third study concentrated on describing the operations within the Center after a telephone call was answered and the fourth study focused on the assignment of patrol units as the output of the Center.

The Command/Control Time Study documented the lapsed time between specific work activity elements which describe the operation of the Command/Control System. This involved a continuous stop watch time study of randomly selected inbound calls. A total of 8,710 calls were sampled and these form a subset of the census calls recorded in the Command/Control Telephone Frequency Count. The timed elements were selected to be independent so that their summation would represent the time to process a call from first ring of the telephone to the point at which the assigned unit has again assumed available status.

The final study was the historical documentation of each patrol district by case load. Data was obtained from the Police Department records to determine the number of assignments made to the patrol unit on station in each patrol district. Since these assignments were made by the Radio Operator, this also provides the work load by district of the Radio Operator. The periodic realignment of districts limited the sampling to the period after March of 1971.

Table 1 summarizes the purpose and type of sampling procedure used for each study. All sampling was performed by the Orlando police department personnel who were trained for the special procedures required by each of the different studies.

TABLE 1

PURPOSE AND TYPE OF SAMPLING PROCEDURES

Name	Purpose	Type Sampling
Command/Control Telephone Frequency	To determine total calls by input sources and the resulting total 602-03's and 602-09's	Census count
Inbound Telephone Rate Study	To determine telephone utilization for inbound calls	Randomly selected days - census of all inbound calls
Time Study	To determine process times for predetermined elements of entire Command/Control operations	Random sampling - continuous stop-watch timing
District Loading Study	To determine patrol unit activity and Radio Operator utilization	Historical Data

2.2 Selection of Activity Elements for the Time Study

The primary purpose of the System Time Study was to determine process times for predetermined elements which describe the Command/ Control operations. The choice of these elements was determined by four factors: ease of measurements, completeness of the operation times, independence from other elements and total of all the elements representative of the entire operation.

Initially it was important that the elements chosen be easily measured. The data logging was to be accomplished by Orlando police department trainees who were not familar with engineering time study techniques. Prior to their assignment they were instructed in a special class in continuous stopwatch techniques. In addition special data forms were designed to facilitate actual data logging and minimize confusion of the trainee (see Figure 6).

The initiating point of each timed element must have an audio or visual cue and a clear and unmistakable termination so that personnel taking the data can accurately measure the elapsed time. Each element must measure one specific activity of the total operation and must be completed before another begins. In other words, each element is independent of preceding elements so that the summation of timed elements will actually describe the total operation of the Command/Control System. Clearly this will not be the case if one element is part of another.

To simulate the Complaint Desk operation three simulation parameters were timed. These were designated "D1", "ANFO", and "F1".

They measure, respectively, the time delay in answering the telephone, the time necessary to gather all required information as well as the decision time and, finally, the time to complete the appropriate form if one is required. The parameter "RAD" is a measurement of the travel time for the form to reach the Radio Operator and an information re-check time used by some Complaint Officers prior to placing the form in the conveyor. The elements separating each of these parameters is either an audio cue, such as a teletype ring or electronic stamp, or a visual cue of the telephone receiver at the ear of the Complaint Officer.

Three parameters were also used to time the Radio-Dispatch function. The "D2" parameter indicates the time delay once the form is available to the Radio Operator and the time for the unit assignment decisions. The total time for the Radio Operator to give the information to the field unit was measured by parameter "CALU". The last parameter which is a measure of the Radio Operator is "D3", the delay time occurring from a unit Status Check. The audio cues for the elements defining these parameters were principally the voice of the Radio Operator calling the assigned unit.

The three remaining parameters were "TRVL", "ANV1", and "ANV2" which are a measure of the time for the assigned unit to travel to the location of need and the investigation time required to clear the incident. The audio cues are the electronic time stamp when the Radio Operator records the 10-6 time and 10-8 time in the appropriate locations on the complaint card.

A maximum of ten simulation parameters were timed and subsequently analyzed statistically. The number of parameters to be timed for any given call depends upon the type of form completed at the Complaint Desk. Table 2 keys the starting and finishing elements of each simulation parameter to the Command/Control Operational Flow Chart in the Appendix.

TABLE 2

ACTIVITY ELEMENTS SELECTED FOR TIME STUDY
TO PROVIDE SIMULATION PARAMETERS

Element Start	Number Finish	Simulation Parameters	Parameter Description
1	2	D1	Time delay in answering telephone
2	3	ANFO	Information gathering and decision time for telephone call
3	4	F1	Total time to complete the necessary forms if one is required
4	5	RAD	Travel time or delay in completed form reaching the Radio-Dispatcher
5	6	D2	Radio-Dispatcher delay in assigning unit
6	7	CALU	Unit information gathering time form Radio-Dispatcher
7	8	TRVL	Unit travel time to address given
8	9	ANV1	Investigation Time
9	10	D3	Status check delay time
10	11	ANV2	Investigation Time

2.3 Sample Size

Each activity element was defined so that it was independent and could be readily sampled; however, statistical information on the elapsed time parameters and for the population was not available. Certain assumptions were, therefore, made to determine the size of the samples since the duration of the sampling and the type of sampling procedure was dependent on sample size. The sample size in turn is dependent on the desired reliability of a sample mean $\bar{x}$ as an estimation of μ.

A two-step process was employed to determine the size of the samples necessary for statistical analysis. The first method was an approximation based on apriori knowledge of the distributions. Apriori knowledge of each variable can be surmised based on its relationship to the other variables.

Parameter "D1" should have a sharply peaked distribution because the Complaint Desk personnel strive to answer each inbound telephone call within four rings of the telephone. The information gathering time (ANFO) is expected to be relatively flat because of the length of time to receive the information varies with the type of call, the method of questioning the caller as well as interruptions to answer other telephone extensions. The time required to complete the necessary forms (F1) should be moderately peaked because the only variables would be inexperience of the Complaint Desk personnel in determining the districts in which the call originates or the concise description of the incident on the form. The travel time of the form to get to the

Radio-Dispatcher to assign a unit (D2) is a function of the load on the channel over which the assignment is to be made; therefore, a relatively flat distribution of this parameter can be expected. The use of "10" codes and "dispatch signals" should result in a moderately peaked distribution for the unit information gathering time (CALU). Travel time (TRVL) is a function of traffic conditions, size of unit and relative location of the unit to the scene of the complaint; therefore, a flat distribution can be anticipated. The investigation time (ANV1 and ANV2) parameters are a function of the type of incident for which the unit was dispatched. The distribution of the parameters was anticipated to be extremely flat since an investigation might take longer than one hour. Very sharply peaked distribution for the status check delay time D3 is anticipated because of the use of signal codes.

Table 3 shows the maximum sample size initially determined for each parameter found by using the graph in the Appendix which presents a family of curves relating sample size n and the ratio of σ/μ for a 90% level.

This initial approach to determining the sample size did not consider the reliability of the statistics for each parameter. The second method for calculating sample size was based on two desired characteristics for the statistics. These are that the standard error of the mean or reliability of the mean be less than 10% of the numerical value of that mean and that the type I or α error be limited to 10%. If these desired statistical characteristics were achieved, a more significant value could then be placed on the standard times for each

simulation parameter thus adding validity to the simulation study and to the resulting recommendations.

TABLE 3

SIMULATION PARAMETERS WITH ASSOCIATED DISTRIBUTION OF TIME AND SAMPLE SIZE

APRIORI DISTRIBUTION SAMPLE SIZE			STATISTICALLY DETERMINED SAMPLE SIZE			
Simulation Parameter	σ/μ	Distribution Characteristics Description	n_1	$\bar{x}$	s	n_2
D1	0.3	Sharply peaked	100	.06	.10	752
ANFO	1.0	Flat	385	.90	2.50	2088
F1	0.5	Moderately peaked	100	1.00	3.20	2771
RAD	0.3	Sharply peaked	100	.50	2.00	4330
D2	1.0	Flat	385	.80	2.80	3315
CALU	0.5	Moderately peaked	100	.50	1.50	2436
TRVL	1.0	Flat	385	8.00	8.00	271
ANV1, ANV2	1.0	Flat	385	12.00	38.00	2714
D3	0.3	Sharply peaked	100	.11	.01	3

Fifty samples of each parameter were taken, the resulting times graphed and the mean and standard deviations calculated. Each parameter exhibited unimodel characteristics about its sample mean. This is reasonable since each parameter represents human reactions to planned actions or activities.

Using the sample statistics as estimates of population parameters, the sampling size for each parameter may be determined using

$$n = \frac{Z^2_{\alpha/2} \cdot \sigma^2}{E^2}$$

where E is maximum difference $|\bar{x} - \mu|$.[1] This expression may be simplified by noting

$$Z^2_{\alpha/2} = (1.645)^2 = 2.706$$

and

$$E^2 = (.1\ \bar{x})^2 = .01\ \bar{x}^2$$

thus

$$n = \frac{s^2}{\bar{x}^2} \cdot (270.6)$$

Table 3 shows the resulting sample size for each parameter under the columns designated "Statistically Determined Sample Size."

2.4 Sampling Procedure

A sampling procedure must be carefully planned and documented. It includes consideration of randomness, recording of data and provision for supervision and accountability for the result.

In the "Command/Control Telephone Frequency Count Study" all incoming and outbound calls from the Command/Control Center were recorded on the form (Figure 6) by a stroke count. If that call resulted in a 602-03 or a 602-09, a stroke count was recorded in the corresponding column. All personnel at the Command/Control Center for all three shifts recorded this information. Each form was dated, the shift indicated and the form signed by the person involved. The study started at 0700 hours on Monday, February 28, 1972, and ran continuously until 0700 Monday, June 5, 1972. The total sampling time was 99 days.

---

[1] Irwin Miller and John E. Freund, Probability and Statistics for Engineers (Englewood Cliffs, New Jersey: Prentice Hall, 1965), page 147.

The "Inbound Telephone Rate Study" was conducted for three randomly selected 24 hour periods (Monday, Tuesday, Thursday). The military time of day was recorded for the time of first ring of every telephone call coming into the Complaint Desk. If a call was from a special agency such as the F.H.P., O.C.S.D., Electric Securities or an ambulance, this information was also noted. The resulting histograms are shown in the Appendix.

While the Telephone Frequency Count was 100% sampling procedure, the "Command/Control Time Study" was designed to gather a random sampling from the population of all incoming telephone calls to Command/Control Center. The trainee started his watch at the first ring and timed each subsequent element in study. He then clocked the next call from first ring to completion. This resulted in a cascading effect on the number of samples taken by parameter. The first parameters would have more samples taken because the percentage of calls followed to completion depended upon the type of inbound call. If a call resulted in the trainee awaiting a 10-8 for more than ten minutes, he wrote the file number down in the appropriate row in the "Comment" column and stopped timing the call. Approximately 15 minutes before the end of his shift, he searched all completed forms to find the file number, subtracted the reported 10-6 time from the reported 10-8 time and entered the result on his time study sheet and noted by circling. A 10-8 could extend over an hour and no useful purpose would be served by the trainee waiting this period of time when he could be sampling other calls.

All times on the time study sheet are in hundreths of a minute unless the number is circled. Circled times are in hours and minutes which were subsequently converted to minutes. The Command/Control Time Study Sheet is shown in Figure 6. In keeping with good time study techniques, each form is dated and signed by the trainee taking the study. Additional information is also required by the time study sheet to facilitate for a more detailed statistical study of the elements. They are shift, type of form completed, type of offense and census tract number.

From the monthly records of the Department, the number of 602-03 calls completed by district were obtained for a period of one year (May, 1971 through April, 1972). Although statistics were available prior to 1971, some district boundaries were changed in March of 1971. These changes could have affected the loading by district and were not considered. Loading by district gives a good indication of the work load of the East and West Radio Dispatchers.

2.5 Descriptive Statistics for Telephone Frequency Count Study

Data for the Telephone Frequency Count Study was continuously recorded from February 28 through June 5, 1972. All inbound and outbound calls were characterized by point of origin and type of form required by the call. All Command/Control work stations with the exception of the Teletype were included in the study.

Four major categories by origin or destination were used to classify the telephone traffic; from public, within Orlando police department, from other agencies and to other agencies. A telephone call

originated by a citizen was recorded in the total column under the "From Public" classification. If police action was subsequently required as a result of this telephone call, either a 602-03 or a 602-09 was logged in the appropriate column under the same classification. Any call from within the Orlando police department was logged under "Orlando Police Department Calls." Similarly if Florida Highway Patrol, Orange County Sheriff's Department, Fire Department or ambulance service originated a call it was recorded under "Calls from Other Agencies." If the outbound call resulted from a 602-03 or a 602-09, the appropriate column was marked.

As indicated by the Operational Flow chart in the Appendix, all telephone calls which are answered by the Radio Operator must be first answered by the Complaint Officer and further be of an emergency or "in progress" type of incident. In Table 4 the Gross Total Calls entry represents all telephone traffic. The Net Total Calls is the Gross Total Calls minus those calls recorded by the Radio Operators. This is a 15.7% reduction of the total telephone traffic. Within each of the four major classifications are three categories: "Total," "602-03" and "602-09." The percentage of Net Calls/Category indicates the observed percentage by category for each classification, that is, 50.9% of all telephone traffic came from the general public. Withing the classification "From Public" 38.5% of those calls resulted in a 602-03 being completed. This column is indicated by the heading "Percentage by Total Classification."

TABLE 4

CUMMULATIVE DATA FOR TELEPHONE CALL STUDY
BY CATEGORY AND CLASSIFICATION

	Gross Total Calls	Radio-Oper. Total Calls	Net Total Calls	% On Net Calls/ Category	% By Total/ Classification
From Public					
Total	32142	356	31786	50.9	54.9%*
602-03	12292	72	12220	85.9	38.5
602-09	2131	20	2111	32.4	6.6
O.P.D. Call					
Total	28147	7772	20375	32.6	79.2*
602-03	2395	1330	1065	7.5	5.3
602-09	4111	943	3168	48.6	15.5
Call from Other Agencies					
Total	5916	572	5344	8.6	64.0*
602-03	797	24	744	5.4	14.5
602-09	1199	51	1148	17.6	21.5
Call to Other Agencies					
Total	7932	2958	4974	7.9	94.7*
602-03	1072	901	171	1.2	3.4
602-09	554	460	94	1.4	1.9

*No action taken or as a result of no police action

Correlation of the data from this study by shift and by day of week is presented in the Appendix. The total telephone traffic for the Command/Control Center varies by shift with third shift double that of first shift. The daily load builds to a peak on Friday with Sunday

the lowest, exhibiting a total variation of 5.9%. However, the percentage of 602-03 and 602-09 is relatively constant showing a total fluctuation of only 3%.

The mean of calls by day is 757 with a standard deviation of 101 calls, where as the mean and standard deviation by shift are: 1st shift $\bar{x} = 164$, $s = 35$; 2nd shift $\bar{x} = 265$, $s = 58$; 3rd shift $\bar{x} = 327$, $s = 72$.

2.6 Descriptive Statistics for Parameters of the Time Study

Raw data on 8710 randomly selected inbound telephone calls was recorded from February 28 through March 31 and from May 15 through June 30. This data was reduced statistically to obtain information which could be used in the simulation.

Initially the elapsed time for each parameter was determined by subtracting the times of the two defining even elements and recording this on the Time Study Sheet. The resulting data was transferred to computer cards on which each line of the Time Study Sheet represented a timed telephone call. A special computer program was then used to determine the mean and standard deviation for each parameter by day of week, by type of form, by shift and by total time to 10-6 and to 10-8. This program and the accompanying printout are included in the Appendix. This program also generated histogram data with a range of $\bar{x}_j \pm 1.96\, s_j$ for each parameter.

The results of the computer analysis for all sample data is shown in Table 5. The two investigation parameters ANV1 and ANV2 were

TABLE 5

DESCRIPTIVE STATISTICS FOR THE SIMULATION PARAMETERS OF THE SYSTEM TIME STUDY

Day of Week / Shift		Response Time to Ring of Phone mins.	Information Gathering Time mins.	Form Completion Time mins.	Travel Time To Radio Operator mins.	Radio Operator Delay mins.	Unit Response Delay mins.	Travel Time To Get To Area mins.	Investigation mins.	Total Time to 10-8 mins.	Total Time to 10-6 mins.
MON	$\bar{X}$	.047	.924	.945	.373	.822	.392	4.535	14.851	22.890	8.039
	S	.039	.935	1.118	.511	1.532	.457	3.588	17.146	17.658	4.221
	N	893	885	206	198	188	164	161	110	896	896
TUES	$\bar{X}$	.046	.913	.894	.459	.649	.432	4.943	17.244	25.582	8.338
	S	.031	1.038	.797	.679	.908	.600	3.525	16.568	17.038	3.973
	N	1507	1497	300	287	270	238	220	118	1507	1507
WED	$\bar{X}$	.053	.911	.900	.597	.872	.402	4.800	13.948	22.483	8.535
	S	.110	1.007	1.941	.772	1.402	.428	3.349	11.533	12.320	4.330
	N	1513	1496	265	248	239	218	199	100	1515	1515
THUR	$\bar{X}$	.052	.864	.825	.504	.709	.416	4.602	17.357	25.329	7.972
	S	.050	.964	.880	.631	1.120	.421	3.219	15.240	15.689	3.729
	N	1297	1284	242	229	216	190	182	92	1301	1301
FRI	$\bar{X}$	.086	.914	.985	.328	.764	.466	4.785	15.580	23.908	8.328
	S	.094	1.084	.724	.496	1.054	.590	3.509	18.199	18.665	4.146
	N	1333	1316	229	220	215	198	180	77	1333	1333
SAT	$\bar{X}$	.054	.997	1.112	.380	.574	.372	4.146	15.307	22.943	7.635
	S	.063	1.037	.885	.563	.755	.514	2.905	18.358	18.667	3.384
	N	1210	1225	212	205	190	179	163	74	1233	1233
SUN	$\bar{X}$	.051	1.094	1.020	.421	1.010	.496	4.421	17.524	26.036	8.513
	S	.048	1.291	1.093	.562	2.033	.806	3.175	16.198	16.776	4.364
	N	923	910	183	184	175	167	153	88	924	924
1st Shift	$\bar{X}$	.077	.945	1.105	.524	.830	.413	3.993	13.958	21.845	7.888
	S	.994	1.121	.988	.749	1.399	.451	2.883	15.958	16.398	3.775
	N	1993	1973	353	341	321	316	288	174	1995	1995
2nd	$\bar{X}$	.050	.859	.891	.379	.657	.421	4.984	18.506	26.747	8.241
	S	.061	.954	1.379	.523	1.313	.675	3.512	18.606	19.073	4.195
	N	3177	3145	625	618	588	504	478	207	3181	3181
3rd	$\bar{X}$	.049	1.004	.915	.464	.837	.436	4.658	15.378	23.741	8.363
	S	.043	1.088	.933	.633	1.200	.484	3.381	14.057	14.634	4.070
	N	3506	3495	632	612	584	534	492	278	3533	3533
TOTAL	$\bar{X}$	.056	.945	.955	.438	.772	.425	4.605	15.973	24.167	8.194
	S	.120	2.796	2.989	1.611	3.494	1.480	8.815	43.178	44.458	10.431
	N	7	7	7	7	7	7	7	7	7	7

combined to give a more accurate description of total time involved. The status check delay time "D3" occurred so infrequently and, as previously indicated, the size of the sample for this parameter was so small that the statistics were omitted from the Table. The mean standard deviation and sample size for all other paramters by day and by

shift are shown. The smallest sample size (74) occurs in the cell "Investigation Time" on Saturday. This sample although relatively small is statistically significant. The population parameters μ and σ are approximated by $\bar{\bar{x}}$ and $s_{\bar{x}}$ shown in the "Total" row.

Analysis of the $s/\bar{x}$ ratios indicates a flat distribution for each parameter. If each day of the week is assumed to be a separate sample, the range of the $\bar{x}$'s for each parameter are closely grouped and normally distributed about the corresponding $\bar{\bar{x}}$. It is noted that in at least one entry for each parameter the standard deviation is much larger than the other values by day of week and dominates the estimate of the population standard deviation.

The histogram for the total sample for each parameter is included in the Appendix. When viewing the histograms caution must be used in interpreting the general shapes. For example, "CALU" would appear to be normally distributed; however, the mean is within the 7th interval, the mode is within the 4th interval and the $S/\bar{\bar{x}}$ ratio is 3.4. The 90% confidence level is 3.12 minutes. The graph only shows intervals to 1.06 minutes because of the extremely small frequencies for greater intervals.

Using the grand mean as the approximation of the population mean for each parameter, analysis of one of the basic design criteria for sample size is required. Where the sample mean by parameter by day of week exceeds the 10% allowable deviation from the grand mean, the Type II or β error must be identified.

In Table 6 the range of each parameter is shown with that day of week exhibiting the greatest deviation outside the 10% range of the population mean. The approximate β error is calculated to determine the probability of accepting that daily mean as a valid sample when it comes from a population beyond the desired 10% reliability interval. As evidenced by the high β error in most of the parameters, additional sampling is required to meet the 10% reliability desired. Each of the days which exhibit high β errors were not sampled sufficiently because of the lack of personnel. Sunday, because of its low input telephone volume, suffered the most from this lack of sampling.

TABLE 6

10% ALLOWABLE DEVIATION RANGE AND MAXIMUM β ERROR BY PARAMETER BY DAY OF WEEK

Parameter	Day of Week	Range in Minutes	Approx. β Error in %
D1	Fri. .086	.050 - .062	30
ANFO	Sun. 1.094	.851 - 1.040	50
F1	Sat. 1.112	.860 - 1.051	50
RAD	Wed. .597	.394 - .482	40
D2	Sun. 1.010	.695 - .849	45
CALU	Sun. .496	.383 - .468	50
TRVL	-	4.144 - 5.066	-
ANV1 + ANV2	Wed. 13.948	14.376 - 17.570	50

2.7 Hypothesis Testing

The data on each parameter describing the Command/Control System process must be statistically tested to establish its degree of validity. Specifically, the sample mean for each parameter was required to approximate the population mean within a specified tolerance to be acceptable.

Typically, statistical hypothesis testing is a methodology comprised of a number of carefully defined steps; formulating the null and the alternative hypothesis, specifying the level of significance, selecting the testing statistic, establishing decision criteria, doing computations and making decisions.

To formulate the null and alternative hypothesis, the mean of the sample means $\bar{x}$ was used as the population mean μ. The basic question was whether there existed any significant difference from this mean and the other means by day and by shift for each of the simulation parameters. Since $\bar{x}$ may be greater or smaller than $\bar{\bar{x}}_T$, a two-tailed testing procedure is indicated. The null and alternative hypothesis can be expressed $H_0 : \bar{x} = \bar{\bar{x}}$; $H_1 : \bar{x} \neq \bar{\bar{x}}$.

A confidence level of 90% was used to be consistant with the confidence level used in determining sampling size. Two types of errors are possible in hypothesis testing. The 90% confidence level is an indication of an α or Type I error, that is, 10% of the time, rejection of the null hypothesis will be made when it should have been accepted. The second type of error is termed β or Type II error. This is committed when the null hypothesis is accepted when it should have been rejected.

The selected testing statistic utilized the Student-t distribution because the small sample size (n = 7) does not support the normal "Z" test statistic and because the population variance was unknown. The degree of freedom for the test will be n - 2 = 5. Two degrees of freedom are lost because the population parameters μ and σ were approximated by $\bar{x}$ and $s_{\bar{x}}$.

To establish the decision creiteria the following theorem was utilized:

> If x is a mean of a random sample size n taken from a normal population bearing a mean and the variance
>
> $$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$
>
> is the value of a random variable having the Student-t distribution with the parameter
>
> $$\nu = n - 1$$ [2]

The corresponding t value for $\nu = 5$ and $\alpha = .10$ is 2.015 for a two-tailed test. The decision criteria is, accept H_0 if $|t_0| < 2.015$ and reject H_0 if $|t_0| > 2.015$[3].

This theorem was used to test each parameter mean and results summarized in Table 7. For Monday "Investigation" the required calculations are as follows:

$$t_{\bar{x}} = \frac{14.851 - 15.973}{17.146/\sqrt{7}} = .17$$

---

[2] Ibid., p. 136.

[3] Ibid., p. 399

and since $|t_0| = .17 < 2.015$ the null hypothesis cannot be rejected with a 90% confidence. Table 7 shows that all $|t_0|$ are less than 2.015; and, therefore, H_0 may not be rejected. Each sample mean does not significantly differ from population estimate .

TABLE 7

RESULTING CALCULATED TO VALUES FOR THE SIMULATION PARAMETER BY DAY AND SHIFT

Day Of Week Shift	Response Time To Ring Of Phone	Information Gathering Time	Form Completion Time	Travel Time To Radio Operator	Radio Operator Delay	Unit Response Delay	Travel Time To Get To Area	Investigation Time	Total Time For 10-6	Total Time For 10-8
MON	t = .61	t = .59	t = .24	t = .34	t = .09	t = .19	t = .05	t = .17	t = .10	t = .19
TUES	.85	.82	.20	.08	.36	.03	.25	.20	.10	.22
WED	.07	.89	.75	.54	.19	.14	.15	.46	.21	.36
THUR	.21	.22	.39	.28	.15	.04	.002	.24	.16	.20
FRI	.06	.76	.11	.59	.02	.18	.14	.06	.09	.04
SAT	.08	.13	.47	.27	.69	.27	.42	.10	.44	.17
Sun	.28	.31	.16	.08	.31	.23	.15	.25	.19	.29
1st SHIFT	.04	0.0	.26	.20	.07	.06	.37	.23	.14	.25
2nd	.17	.16	.08	.20	.09	.01	.23	.24	.02	.23
3rd	.28	.09	.07	.07	.09	.04	.19	.07	.07	.05

BY DAY	BY SHIFT
1 Hypothesis: H_0: $\bar{x} = \bar{\bar{x}}$ H_1: $\bar{x} \neq \bar{\bar{x}}$	1 Same As By Day
2 Level of Significance: $\alpha = 0.05$	2 Same As By Day
3 Test Statistic: $t_o = \lvert(\bar{x} - \bar{\bar{x}})/s/\sqrt{n}\rvert$ $\nu = 5$, $n = 7$	3 $\nu = 1$, $n = 3$
4 Decision Criteria: Reject H_o iff $t_o > 2.015$	4 Reject H_o iff $t_o > 6.314$

2.8 Chi-squared Goodness of Fit Test

Initially, the histogram for each parameter was examined for basic distribution characteristics. In general, each parameter exhibited a positive skewness because it was constrained to start at zero time and had no upper time limit. This was reflected in the standard deviation which was relatively large and characteristic of flat distributions.

A Chi-squared goodness of fit test was performed on each parameter of the study in an attempt to define a closed form of a probability density function for the sample.[4] Expected frequencies using the Poisson, Normal, Gamma and Log-Normal distributions were calculated and compared with the actual frequencies. Within the Log-Normal and Gamma functions α was varied from $\alpha = 1$ to $\alpha = 10$ in increments of 1.0, β was varied from $\beta = 0$ to $\beta = 5.0$ in increments of 0.2. None of the test functions approximated the sampled frequencies within 90% confidence levels of the Chi-square test.[5] The primary reason for this is the high $s/\bar{x}$ ratio and a peaking of each frequency at lower time intervals. In distribution histograms of each parameter the mean is to the right of the mode: therefore, the Normal and the Poisson distributions would be poor approximations. The Gamma functions with $\beta > 0$ do not fit the sample distributions in the lower time intervals but do approximate the sample when the time interval is larger than the 15th interval.

---

[4] Ibid., p. 202-203

[5] Ibid., p. 400

2.9 Summary

In order to statistically simulate the Command/Control System, the input, output and intermediate operational steps must not only be defined, they must be described in quantitative terms suitable to the simulation model. The data was obtained primarily from random sampling of the operations as they occurred although historical data was also used where available.

The timed elements were selected on the basis that they were functionally independent, could be readily measured and would provide the required degree of validity for the model. Each element had an audio or visual cue which clearly indicated the beginning and end of the activity. Times were obtained by using stopwatches and standard work sampling techniques.

The sampling procedure was carefully planned and documented to ensure randomness and validity of the data. A two-step process was used to determine the sample size since no knowledge of μ or σ for the population existed. Initially, the sample size was approximated using apriori knowledge of key personnel in the Center and then refined using desired design criteria for each timed element based on a select sampling.

Police trainees were used to obtain the data on a 24-hour basis. Since specific skills not associated with police training were required, special classes were conducted for those personnel participating in the program. The classes were primarily concerned with practicing stopwatch techniques and entering data correctly on the appropriate forms.

The raw data was reduced by special computer program to determine descriptive statistics and histogram information for each element. Validation of the sample statistics was accomplished by statistical hypothesis testing. This analysis was performed to identify any significant difference between sample means by day of week and shift and the population mean. Two-tailed test and the Student-t statistic were used to accomplish the analysis. All sample data so tested was within the 90% confidence interval.

Although the daily volume of telephone calls varied by day of week, the percentage of calls which produced police action was relatively constant. The percentage variation by day of week was twice the percentage variation of the total 602-03's and 602-09's completed at the complaint desk for that day.

Saturday and Sunday exhibited a marked decrease in interdepartmental telephone traffic. This was probably due to the reduction in supportive personnel over the weekend. However, the lower interdepartmental traffic was in contrast to increased telephone traffic from the general public on Saturday with Sunday the lowest volume day of the week.

CHAPTER III

SIMULATION RESULTS

3.1 Introduction

With the completion of the statistical simulation of the Command/Control Center, areas of possible improvement and procedural changes are apparent. Each observation and recommendation is supported by the statistical analysis of one or more of the studies previously described.

Areas of additional work are many because of the lack of basic applications of industrial engineering techniques. The total systems approach to the operation of Command and Control when applied to police operations should include methods improvement and form design to reduce the double checking of the forms completed by the Complaint Desk. It would include laying out the Center to eliminate the conveyor. The control console and active status file are designed for only two radio operators allowing for no future expansion.

Under the present training conditions, layout and forms, the civilian and uniformed personnel operate as effectively as possible. In many instances their work efficiency is far superior to that expected in industry.

3.2 Observations and Recommendations

Based on operational analysis of the Command/Control System and statistics from the sample studies, a number of observations were made, some of which clearly indicate action toward improved operation.

Statistics from the Telephone Frequency Count Study generally indicate that much of the telephone traffic handled in the Communications Center is information only. A more specific examination by type/origin further indicates that many of the calls might be eliminated or shunted around the Center.

. Almost half (49%) of all 602-09's completed by the Complaint Desk personnel are a result of interdepartment communications. An example would be a personal request that an officer on field assignment call the originating party. It appears this type of traffic could be received and handled by the Bureau watch commander. If it affected the status of the field unit, he would so notify the center by radio or callbox.

. In addition, 79% of all interdepartment calls handled at the Complaint Desk do not require subsequent action. These are information queries and could be answered by the information desk sergeant.

. 64% of all calls from other public safety agencies result in no Orlando Police action. This indicates that the computerized information pool among police agencies within the immediate area must be upgraded.

. Further, of those calls from the public requiring processing by the Complaint Desk Officer, only 45% result in a patrol unit being

dispatched. It appears that the public expects more service and is prone to exagerate an incident beyond the actual severity. It is realized, however, that this situation cannot be readily changed and the Complaint Desk must continue to respond to such calls.

. 46% of all calls to other agencies made by the radio operators are a result of no police activity since calls concerning police business must be as a result of a 602-09 or a 602-03.

. The Inbound Telephone Rate Study indicated that the call rate could be generally described by some form of experimental distribution. However, the rate was translated to time between call and frequency histograms prepared by shift for the simulation model. It was noted that the call rate typically decreased from first to third shift as seen in the Appendix.

. Examination of the data from the District Loading Study indicated a consistent difference between East and West side operations. Typically, the East side districts average 55% of all calls. It is noted, however, that these are calls only and, therefore, not necessarily indicative of the actual workload which would consist of incidents requiring patrol unit response and investigation.

The greatest number of pertinent observations on the effectiveness of the operations can be derived from the Time Study data.

. There is no significant difference in response time performance of the Command/Control Center by day of week or by shift. This indicates a uniform operation not subject to differences of day or shift.

. The Time To Answer Phone variable D1 has a peaked distribution. The Complaint Desk personnel answer 73% of the calls within three rings or 0.13 minutes.

. Information Gathering Time variable ANFO is characterized by a flat distribution. However, the mean and standard deviation for a 602-09 and a 602-03 are $\bar{x}$ = .73, s = .74 and $\bar{x}$ = 1.01, s = .79 respectively. Both of these distributions are considerably more peaked indicating that once the decision to dispatch a unit has been made by the Complaint Officer, a routine of information gathering is followed. A longer average time for a 602-03 is indicative of the additional information required by the form.

. The Form Completion Time variable F1 has a mean and standard deviation for a 602-03 greater than that of a 602-09, indicating a longer time required to complete a 602-03. This parameter is also a good indication of time which under present operation is wasted due to work duplication. In a great many cases F1 time is information transfer time. The appropriate work was not being completed while the caller was still on the telephone. This is an indication of improper procedure since most of the F1 time could be eliminated by completing the required form while gathering the information.

. The Travel Time To Radio Operator RAD is governed by the belt speed of the card conveyor. Typically, .12 minutes is required for the card to reach the Radio Operator's station. The remaining 0.32 minutes is spent double checking the information on the form. The extremely

large standard deviation would indicate poor procedures in completing the form; that is, no consistent pattern is followed when completing the form.

. The Radio Operator Delay D2 has a relatively high mean time and indicates the decision process of assigning the nearest available unit. The very high standard deviation indicates high traffic on the radio as well as a delay in recognizing that a form is on the conveyor belt. A better designed work station would greatly reduce both the mean and standard deviation of this parameter.

. The Unit Response Delay CALU includes both transmission time and delay in unit response. The use of "10 codes" and signal codes should convey all pertinent information including the address within .25 minutes. The additional time is dead air time awaiting the unit reply to the call from the Radio Operator. The relatively large standard deviation indicates congested air traffic, repetition of information and delay of the unit to respond to its initial call.

. The Travel Time To Get To Area TRVL shows no significant difference in the mean by shifts which indicates traffic conditions are not the primary delaying factor but rather the units relative location within the patrol district. The average travel time per call could be significantly reduced by a car locator system and possible realignment of the patrol districts.

. Investigation Time ANV1 has a uniform distribution whose mean is dependent upon the nature of the investigation. However,

possible procedure changes are indicated because the function of the patrol unit is to patrol. When a unit is detained for up to one and one half hours with an investigation another unit must cover that patrol area.

. The 602-03 total response time to 10-4 is $\bar{\bar{x}}$ = 3.72 and s = 2.11 minutes. 54% of the mean time is involved with gathering the information and then transferring to the 602-03 form.

. The 602-03 total response time to 10-6 is $\bar{\bar{x}}$ = 8.19 and s = 10.56 minutes. 55% of this average time is unit travel time.

. The 602-03 total response time to 10-8 is $\bar{\bar{x}}$ = 24.17 and s = 44.45 minutes. 66% of this time is investigation.

3.3 Areas of Future Development

Several areas are now ready for the application of basic industrial engineering principles in layout and methods improvement. These smaller projects could be accomplished by two or three man teams in a project oriented course under the direction of a professor knowledgeable with the Command and Control function of the police.

The first such project would be oriented towards methods improvement in the form design of the 602-03 and the 602-09. This form could be designed so that the Complaint Officer could complete the form while in voice contact with the complainant. This would reduce the double checking and the total time involving the Complaint Officer.

The second methods improvement oriented project would study the method of getting the information on the completed form to the

unit with a minimum time delay. This project would include revising the layout of the Command/Control rooms and possibly combining the Complaint Desk and Radio Operator functions. Staffing would be greatly affected and therefore any study involving the layout or procedural changes must include the staffing requirements.

The command console in the radio room is the focal point of radio communication. This piece of equipment should be redesigned with methods and human factors principles the prime consideration. The use of a predetermined time system such as Master Standard Data or Methods Time Measurement would reveal many combined motions which are difficult to perform even after practice because of the distances involved.

The greatest aid to the present operation can be realized by the development of effectiveness measurement criteria. The work presented in the statistical analysis of the operation of the Complaint Officer and Radio Operator could form the basis for this development. Since the primary objective of the Command/Control Center is to process each call with a minimum delay, the lapse time at each step could become part of this effectiveness. Through-put or the number of calls processed by type is extremely important in manning, only when accurate times can be affixed to each call. Thus, utilization factors may be established by operation and personnel may be evaluated for proper methods or need for training.

Within the scope of this statistical study, future development in the area of more sampling is indicated. The actual number of samples

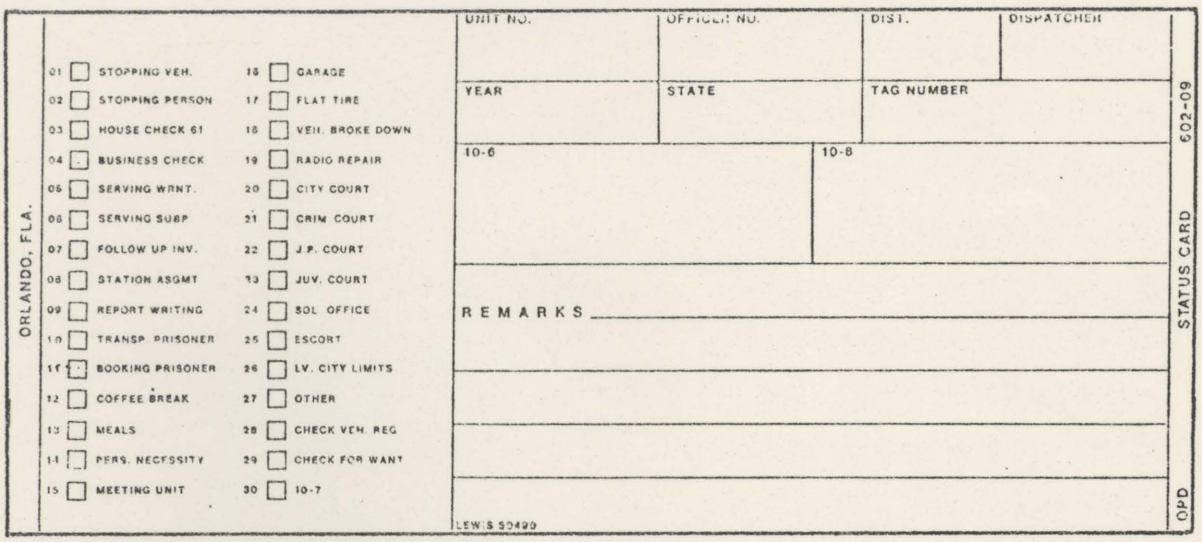
by parameter should be increased to minimize the Type II errors. This is particularly important if the mean values for the parameters are used to develop utilization factors. The shortened sampling periods were due to the scheduling of the Police Academy which the trainees had to attend.

With an increased sample size available, the interactions of day, shift and form may be analyzed. It is doubtful that these second and third order interactions have any significance; however, they should be considered.

APPENDIX

TABLE OF CONTENTS

FORM 602-09



FORM 602-03

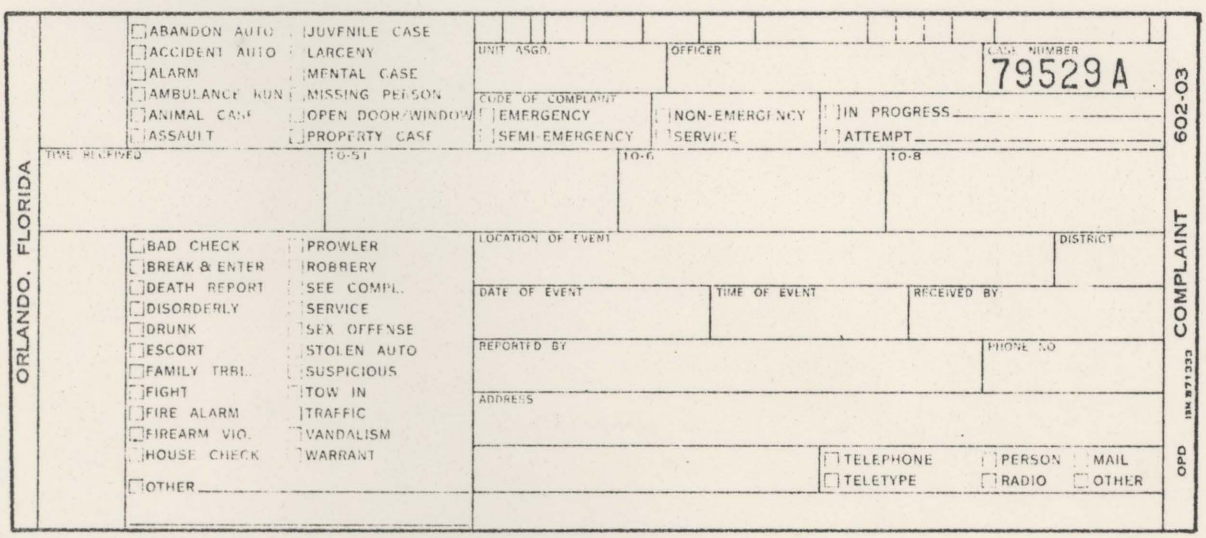


Fig. 7.--Types of forms completed by the Complaint Desk and Radio Operator.

FUNCTIONAL BLOCK FLOW CHART
INTERNAL MODE

COMPLAINT DESK FUNCTION
"Internal Mode"

- MONITOR CIVIL DEFENSE NETWORK PHONE
- BLOW NOON CIVIL DEFENSE WHISTLE ON EVERY MONDAY
- RELEIVE RADIO AND/OR T/T OPERATOR WHEN NECESSARY
- COLLIATE AND FILE 602-03 AND 602-09

RADIO DISPATCHER FUNCTION
"Internal Mode"

- RECORD ACTION TAKEN AND TIME ON BACK OF 602-03 OR 602-09
- ASK FOR FORM 602-03 FROM COMPLAINT DESK
- OBTAIN 602-03.

UNIFORM
COMMAND FIELD UNIT
"Internal Mode"

- REVIEW AND RECOMMEND DISCIPLINARY ACTION
- REVIEW MANPOWER DISTRIBUTION WITH THE SGTS.
- REVIEW CRIME STATISTICS BY TYPE AND LOCATION WITH SGTS.
- LISTEN TO PERSONAL PROBLEMS OF MEN THAT THE SGTS. COULD NOT HANDLE
- ENFORCEMENT OF CIVIL SERVICE AND O.P.D. RULES
- REVIEW VACATION SCHEDULE

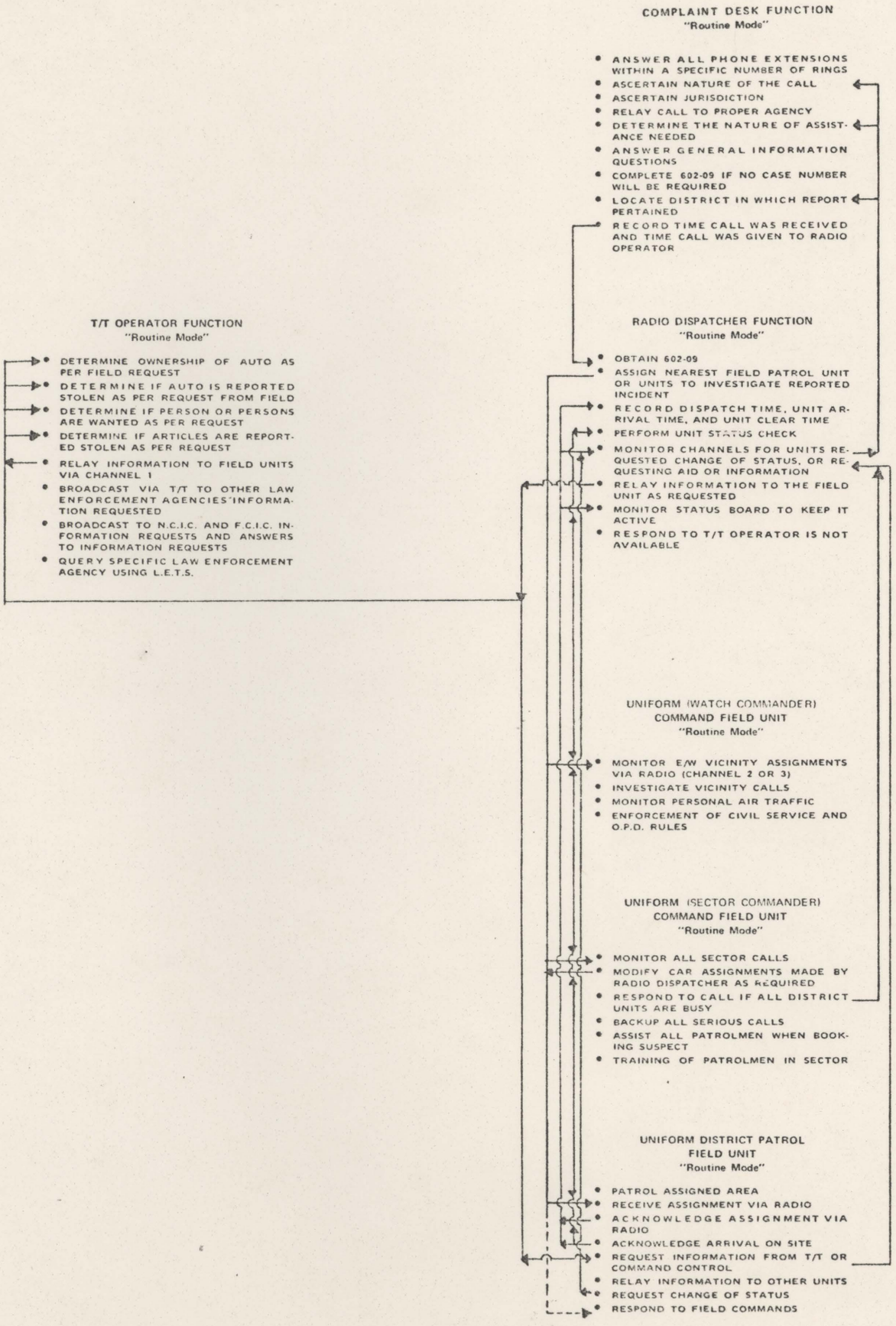
UNIFORM (SECTOR COMMANDER)
COMMAND FIELD UNIT
"Internal Mode"

- INVESTIGATE MISCONDUCT AND REPORT TO COMMANDER VIA WRITTEN REPORT
- REVIEW CRIME STATISTICS AND MANPOWER DISTRIBUTION WITH LT.
- PREPARE VACATION SCHEDULE
- LISTEN TO PERSONAL PROBLEMS OF THE MEN
- CONDUCT 15 MINUTE A.M. INSPECTION

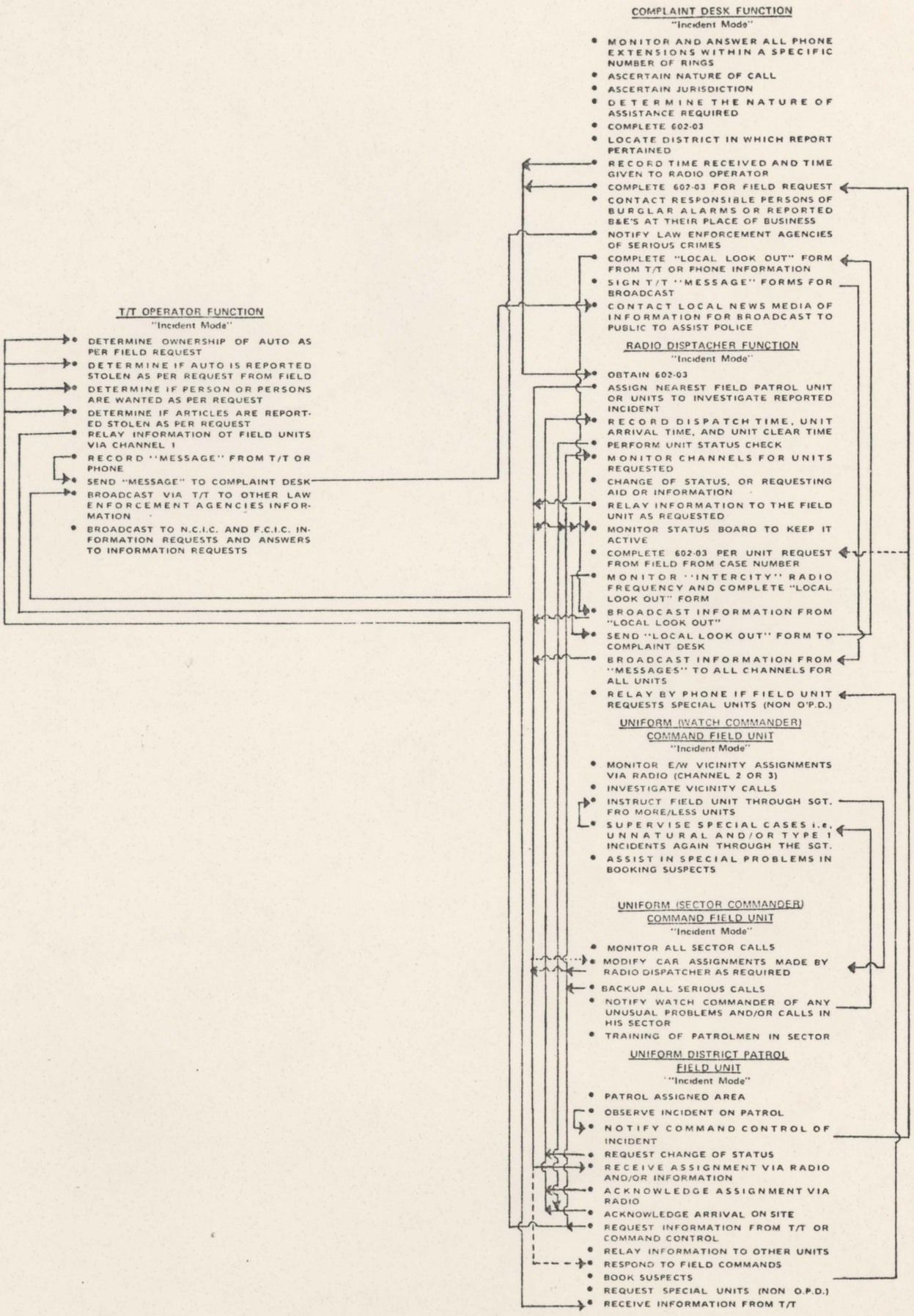
UNIFORM DISTRICT PATROL
FIELD UNIT
"Internal Mode"

- TESTIFY AS REQUIRED
- ATTEND WATCH MEETING
- OBSERVE ALL CIVIL SERVICE AND O.P.D. RULES AND REGULATIONS
- SEEK ADVICE ON PERSONAL PROBLEMS FROM SUPERVISORS

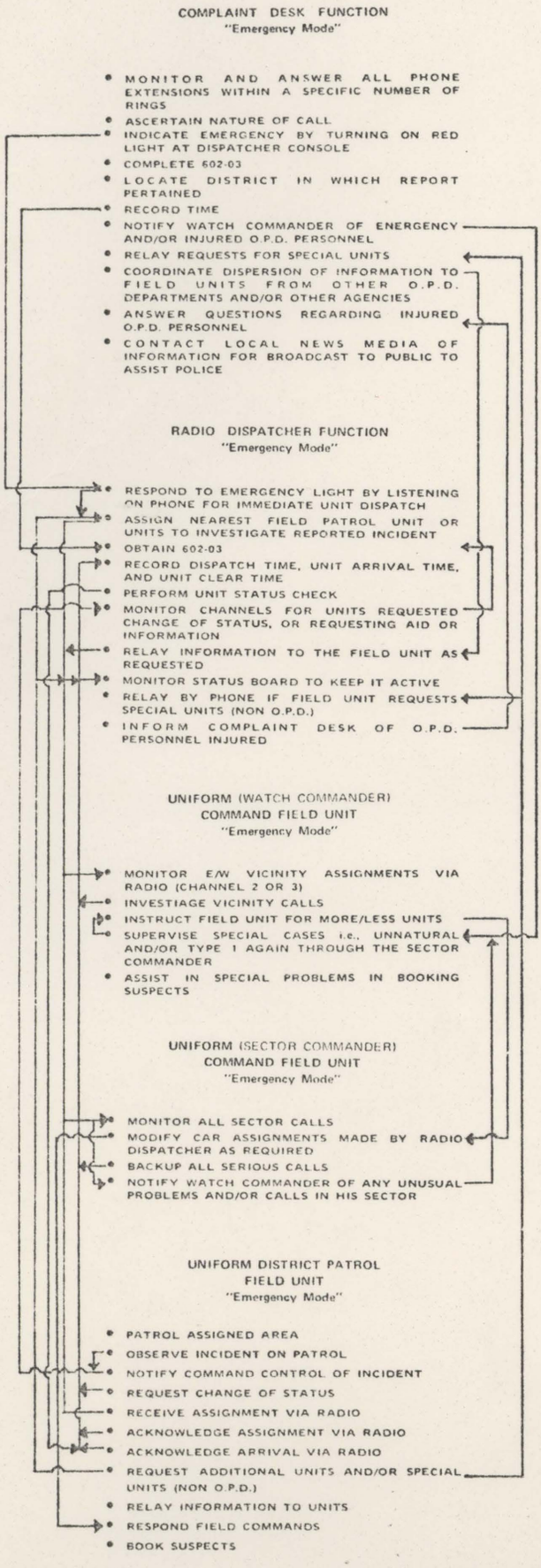
FUNCTIONAL BLOCK FLOW CHART
ROUTINE MODE

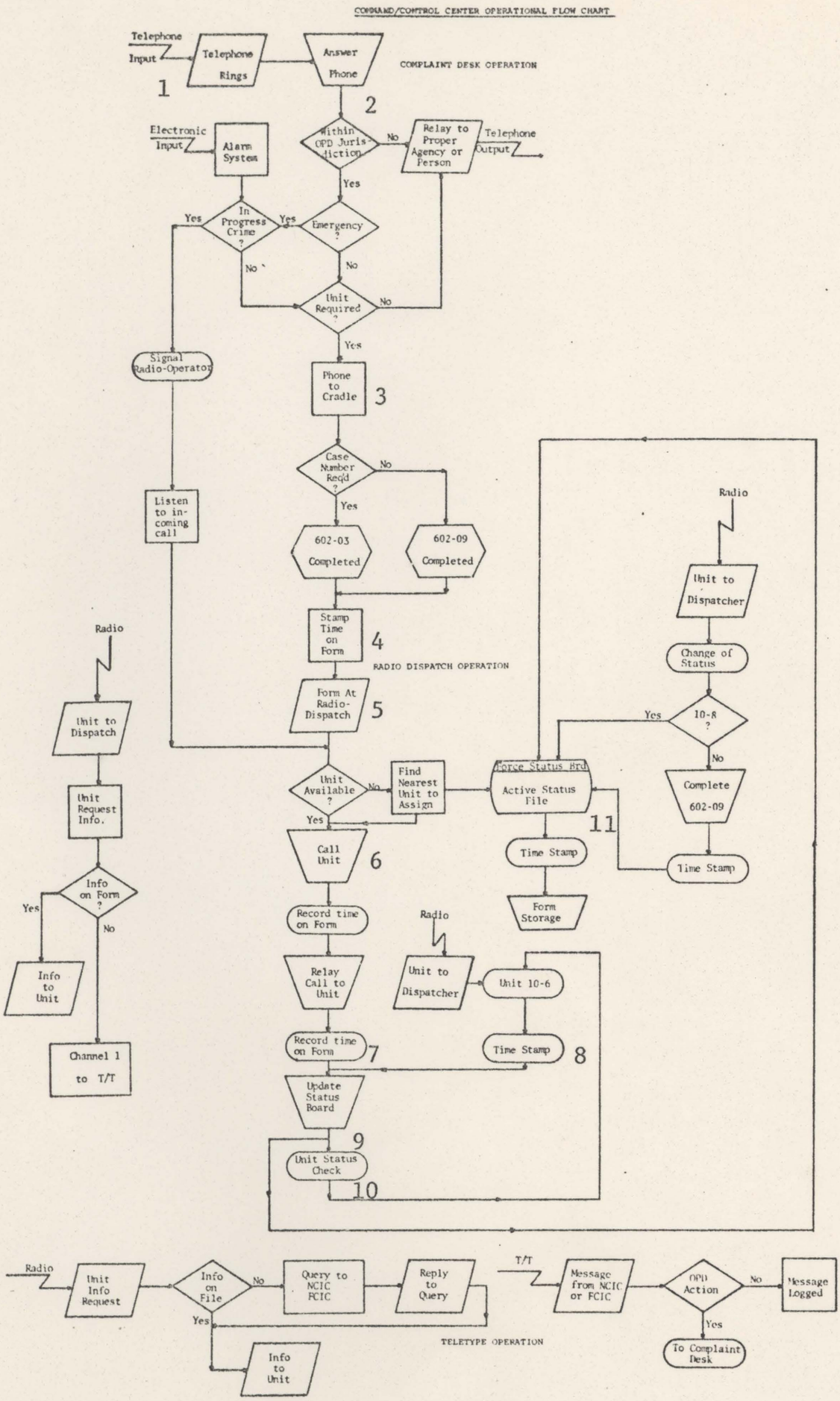


FUNCTIONAL BLOCK FLOW CHART
INCIDENT MODE



FUNCTIONAL BLOCK FLOW CHART
EMERGENCY MODE




COMMAND/CONTROL CENTER OPERATIONAL FLOW CHART
Telephone Input
Telephone Rings
Answer Phone
COMPLAINT DESK OPERATION
1
2
Electronic Input
Alarm System
Within OPD Jurisdiction
No
Relay to Proper Agency or Person
Telephone Output
Yes
In Progress Crime ?
Yes
Emergency ?
Yes
No
No
Unit Required ?
No
Yes
Signal Radio-Operator
Phone to Cradle
3
Case Number Reqd ?
No
Yes
Listen to incoming call
602-03 Completed
602-09 Completed
Stamp Time on Form
4
RADIO DISPATCH OPERATION
Radio
Unit to Dispatch
Form At Radio-Dispatch
5
Unit Request Info.
Info on Form ?
Yes
No
Info to Unit
Channel 1 to T/T
Unit Available ?
No
Find Nearest Unit to Assign
Force Status Brd
Active Status File
Yes
Call Unit
6
Record time on Form
Relay Call to Unit
Record time on Form
7
Update Status Board
9
Unit Status Check
10
Radio
Unit to Dispatcher
Unit 10-6
Time Stamp
8
Time Stamp
Form Storage
11
Radio
Unit to Dispatcher
Change of Status
10-8 ?
Yes
No
Complete 602-09
Time Stamp
Radio
Unit Info Request
Info on File
No
Yes
Query to NCIC FCIC
Reply to Query
T/T
Message from NCIC or FCIC
OPD Action
No
Yes
Message Logged
To Complaint Desk
Info to Unit
TELETYPE OPERATION

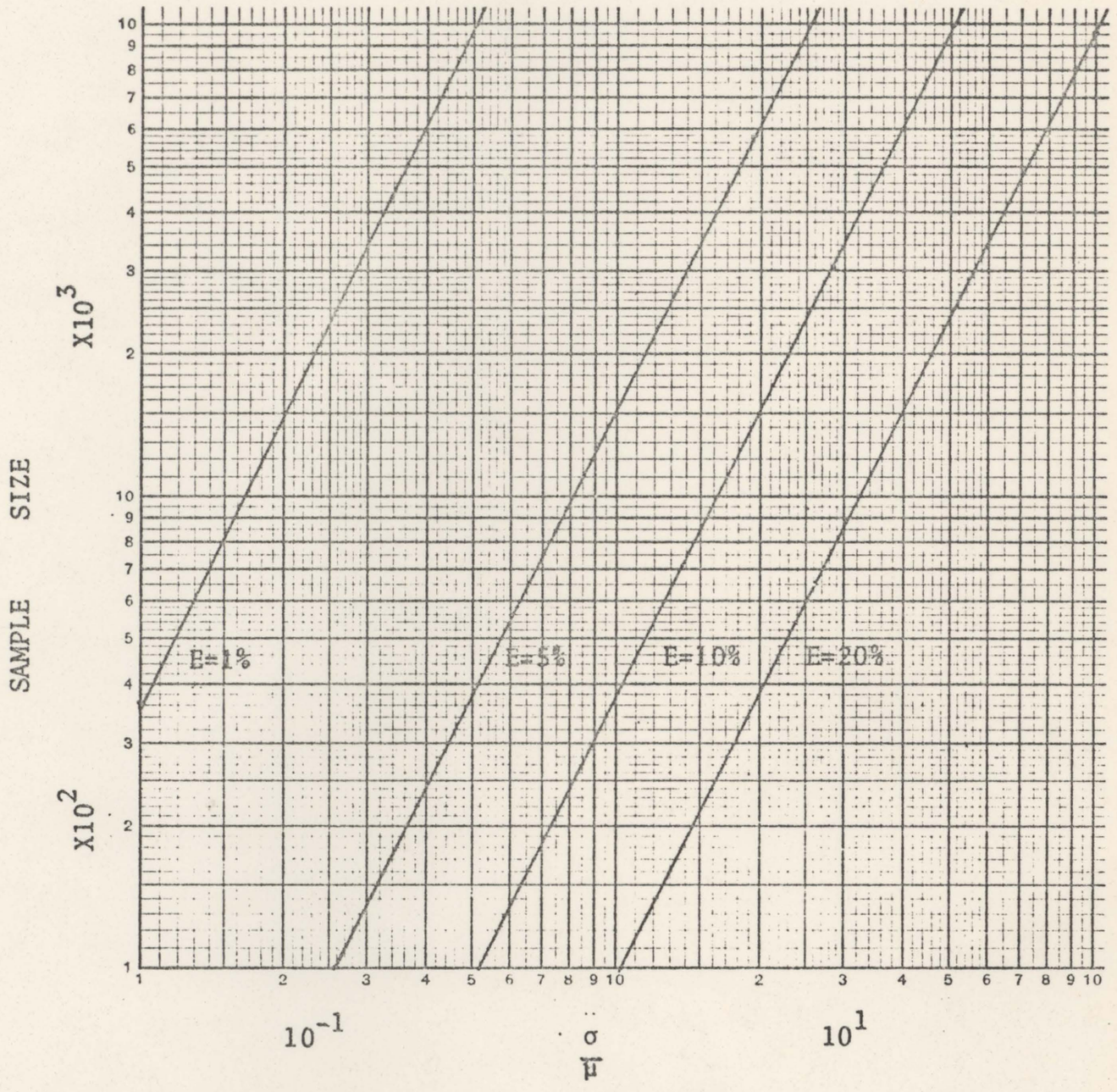
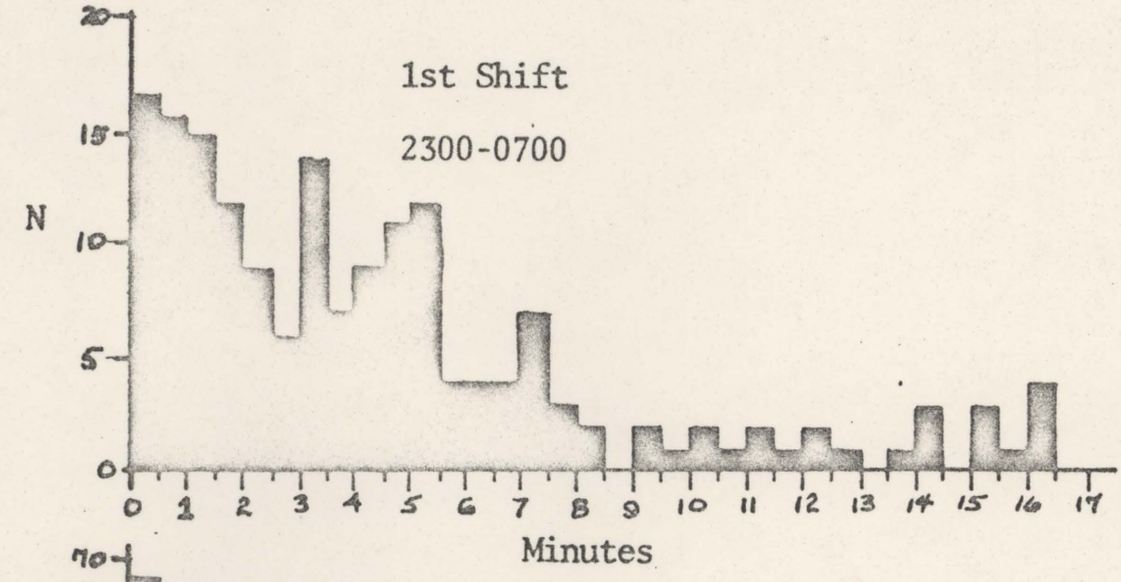
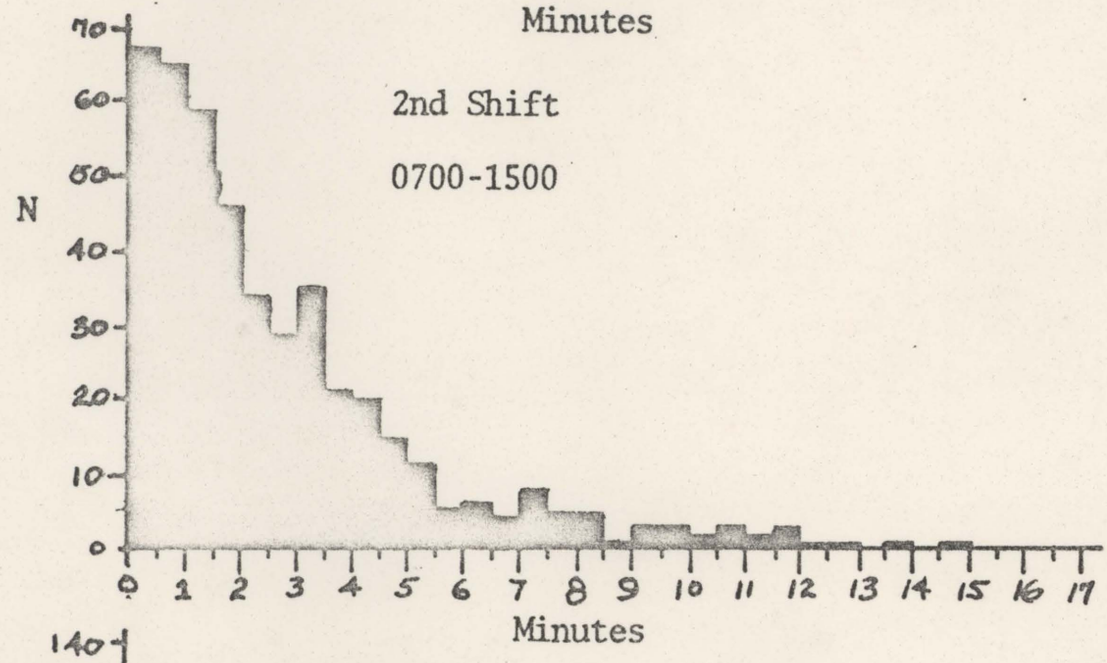


Fig. 8.--90% Confidence Level of Sample Size for Population Ratios.

INBOUND TELEPHONE FREQUENCY HISTOGRAM





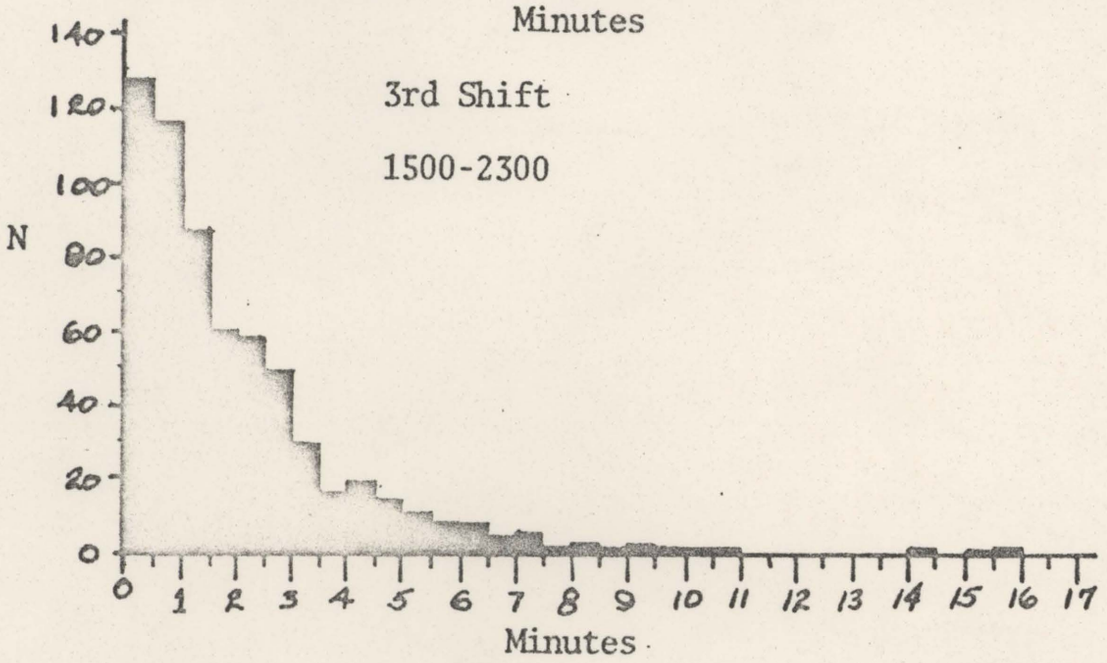


TABLE 8

TELEPHONE FREQUENCY COUNT STUDY DATA SUMMARY

CUMMULATIVE DAILY TOTALS

Day	Total Calls	Total 602-03	Total 602-09	% Of Grand Total	% Of 602-03	% Of 602-09
MON	10049	2293	1030	13.9%	22.8%	10.2%
TUES	10656	2297	1010	14.7	21.6	9.5
WED	10983	2219	1169	15.5	20.2	10.6
THUR	10484	2245	1047	14.5	21.4	10.0
FRI	11618	2701	1228	16.0	23.2	10.6
SAT	11163	2646	883	15.3	23.7	7.9
SUN	7380	1815	543	10.1	24.8	7.4
TOTAL	74137	16212	6910			
AVG	757	165	71	14.3%	22.5%	9.5%

CUMMULATIVE SHIFT TOTALS

Shift	Total Calls	Total 602-03	Total 602-09	% Of Grand Total	% Of 602-03	% Of 602-09
1st	16067	3080	1411	21.7%	19.2%	8.8%
2nd	26067	5664	2505	35.2	21.7	9.6
3rd	32003	7472	2994	43.1	23.3	9.4
TOTAL	74137	16216	6910			

```
      REAL MEAN(8 )
      INTEGER DAY,SHIFT,FORM,C,CT(8 ,51),TIME
      DIMENSION IT(51),IC(51)
      DIMENSION R(8 ),Q(8 ),SIGMA(8 ),T(10,51)
      DIMENSION V(8 ),S(8 ,7,3,3),SQ(8 ,7,3,3),CI(8 ,7,3,3)
      DIMENSION SDV(8 ,7),SQDV(8 ,7),CDV(8 ,7),SFV(8 ,3),SQF-
                                                V(8 ,3),CFV(
     18 ,3),SSV(8 ,3),SQSV(8 ,3),CSV(8 ,3),SD8(7),SQD8(7),CD-
                                                8(7),SF8(3),
     2SQF8(3),CF8(3),SS8(3),SQS8(3),CS8(3),SD6(7),SQD6(7),CD-
                                                6(7),SF6(3),
     3SQF6(3),CF6(3),SS6(3),SQS6(3),CS6(3)
      DIMENSION VMD(8 ,7),VSGD(8 ,7),VMD8(7),VSGD8(7),VMD6(7-
                                                ),VSGD6(7),
     1VMF(8 ,3),VSGF(8 ,3),VMF8(3),VSGF8(3),VMF6(3),VSGF6(3)-
                                                ,VMS(8 ,3),
     2VSGS(8 ,3),VMS8(3),VSGS8(3),VSGS6(3),VMS6(3)
   52 FORMAT(/////,35X,'DATA REDUCTION FOR THE COMMAND/CONTR-
                                                OL SIMULATIO
     1N',/,44X,'OF THE ORLANDO POLICE DEPARTMENT',/,50X,'BY -
                                                  GERALD LOC
     2ASALE',/////)
  100 FORMAT(2I1,5X,8F6.2,14X, I1)
  200 FORMAT(1H1,/////,43X,'MEAN AND STANDARD DEVIATION BY D-
                                                AY',//)
  300 FORMAT(28X,8F8.3)
  301 FORMAT(28X,8F8.0)
  400 FORMAT(1H1,///,31X,'MEAN AND STANDARD DEVIATION FOR A -
                                                UNIT TO CLEA
     1R THAT CALL',/,54X,'TIME TO 10-8',//)
  500 FORMAT(40X,F10.3, 5X,F10.3, 5X,F10.3)
  600 FORMAT(///    ,30X,'MEAN AND STANDARD DEVIATION OF TIM-
                                                E FOR UNIT T
     1O GET TO SCENE' ,//)
  700 FORMAT(28X,8F8.3)
  701 FORMAT(28X,8F8.0)
  900 FORMAT(46X,F8.3,2X,F8.3,2X,F8.0,/)
 1000 FORMAT(// ,38X,'MEAN AND STANDARD DEVIATION BY TYPE OF-
                                                FORM',/,54X
     1,'TIME TO 10-8',//)
 1001 FORMAT(// ,38X,'MEAN AND STANDARD DEVIATION BY TYPE OF-
                                                FORM',/,54X
     1,'TIME TO 10-6',//)
 1100 FORMAT(1H1,33X,'MEAN AND STANDARD DEVIATION OF EACH VA-
                                                RIABLE BY SH
     1IFT',//)
 1101 FORMAT(//,42X,'MEAN AND STANDARD DEVIATION BY SHIFT',/-
                                                ,54X,'TIME T
     1O 10-8',/)
 1102 FORMAT(//,42X,'MEAN AND STANDARD DEVIATION BY SHIFT',/-
                                                ,54X,'TIME T
```

```
     1O 1O-6',/)
 1103 FORMAT(30X,'VARIABLE D1',' = ' ,'THIS VARIABLE IS THE -
                                          TOTAL TIME T
     1O ANSWER THE',/,35X,'TELEPHONE',/)
 1104 FORMAT(30X,'VARIABLE  ANFO',' = ' ,'THIS VARIABLE IS T-
                                          HE TOTAL TIM
     1E TO GATHER',/,35X,'ALL THE INFORMATION FROM THE TELEP-
                                          HAONE CALL',
     2/)
 1105 FORMAT(30X,'VARIABLE  F1',' = ' ,'THIS VARIABLE IS THE-
                                           TOTAL TIME
     1TO CHOOSE ',/,35X,'AND THEN COMPLETE THE APPROPRIATE F-
                                          ORM',/)
 1106 FORMAT(30X,'VARIABLE  RAD',' = ','THIS VARIABLE IS  TH-
                                          E TOTAL TIME
     1 FOR THAT FORM',/,35X,'TO GET TO THE RADIO-OPERATOR',/-
                                          )
 1107 FORMAT(30X,'VARIABLE  D2',' = ','THIS VARIABLE IS THE -
                                          TOTAL TIME F
     1OR THE ',/,35X,'RADIO-OPERATOR TO READ AND ASSIGN A UN-
                                          IT',/)
 1108 FORMAT(30X,'VARIABLE  CALU',' = ' ,'THIS VARIABLE IS T-
                                          HE TOTAL TIM
     1E FOR THE',/,35X,'RADIO-OPERATOR TO GIVE THE INFORMATI-
                                          ON TO THE UN
     2IT',/)
 1109 FORMAT(30X,'VARIABLE TRVL',' = ' ,'THIS VARIABLE IS TH-
                                          E TOTAL TIME
     1 FOR THE',/,35X,'UNIT TO GET TO THE ASSIGNED LOCATION'-
                                          ,/)
 1110 FORMAT(30X,'VARIABLE  ANV1',' = ' ,'THIS VARIABLE IS T-
                                          OTAL INVESTI
     1GATION TIME',/,35X,'FOR THAT CALL',/)
 1113 FORMAT(45X,'THE TOTAL NUMBER PER CATEGORY',/)
 1114 FORMAT(42X,'THE MEAN FOR EACH ELEMENT IS AS FOLLOWS',/-
                                          )
 1115 FORMAT(41X,'THE STANDARD DEVIATION OF EACH ELEMENT IS'-
                                          ,/)
 1200 FORMAT(3X,I4,8F6.2)
 1201 FORMAT(1H1,51X,'INBOUND FREQUENCY',///,48(54X,2I6,/))
 1300 FORMAT(51(28X, 4(F7.3,1X,I5,3X),/),//)
 1400 FORMAT(1H1,//,51X,'FREQUENCY POLYGON',//,28X,4(F8.3,8X-
                                          ),/,28X, 4(F
     18.3,8X),/)
 1600 FORMAT(1H1,25X,'MEAN AND STANDARD DEVIATION OF EACH VA-
                                          RIABLE BY TY
     1PE OF FORM COMPLETED',//)
C
C
      REWIND 1
```

```
      NN=1
      IN=6
      DO 24 J=1,8
      DO 24 K=1,7
      DO 24 L=1,3
      DO 24 M=1,3
      S(J,K,L,M)=0.
      SQ(J,K,L,M)=0.
      CI(J,K,L,M)=0.
      SDV(J,K)=0.
      SQDV(J,K)=0.
      CDV(J,K)=0.
      SFV(J,L)=0.
      SQFV(J,L)=0.
      CFV(J,L)=0.
      SSV(J,M)=0.
      SQSV(J,M)=0.
      CSV(J,M)=0.
      SD8(K)=0.
      SQD8(K)=0.
      CD8(K)=0.
      SF8(L)=0.
      CD8(K)=0.
      SQF8(L)=0.
      CF8(L)=0.
      SS8(M)=0.
      SQS8(M)=0.
      V(J)=0.
      SIGMA(J)=0.
      MEAN(J)=0.
      Q(J)=0.
      R(J)=0.
      SD6(K)=0.
      SQD6(K)=0.
      CD6(K)=0.
      SF6(L)=0.
      SQF6(L)=0.
      CF6(L)=0.
      SS6(M)=0.
      SQS6(M)=0.
      CS6(M)=0.
      CS8(M)=0.
      VMD6(K)=0.
      VMD8(K)=0.
      VMF8(L)=0.
      VMF6(L)=0.
      VMS8(M)=0.
      VMS6(M)=0.
   24 CONTINUE
      DO 25 I=1,10
```

```
      DO 25 J=1,51
      IT(J)=0.
      IC(J)=0.
      T(I,J)=0.
      CT(I,J)=0.
   25 CONTINUE
    1 READ(NN,100) DAY,SHIFT,(V(J),J=1, 8),FORM
      K=DAY
      L=FORM
      M=SHIFT
      CD8(K)=CD8(K)+1.
      CF8(L)=CF8(L)+1.
      CS6(M)=CS6(M)+1.
      CS8(M)=CS8(M)+1.
      CD6(K)=CD6(K)+1.
      CF6(L)=CF6(L)+1.
      DO 2 J=1,8
   47 IF(V(J).EQ.0.) GO TO 2
      S(J,K,L,M)=S(J,K,L,M)+V(J)
      SQ(J,K,L,M)=SQ(J,K,L,M)+V(J)**2.
      CI(J,K,L,M)=CI(J,K,L,M)+1.
    2 CONTINUE
      IF(DAY.NE.0) GO TO 1
      DO 3 J=1,8
      DO 3 K=1,7
      DO 3 L=1,3
      DO 3 M=1,3
      SDV(J,K)=SDV(J,K)+S(J,K,L,M)
      SQDV(J,K)=SQDV(J,K)+SQ(J,K,L,M)
      CDV(J,K)=CDV(J,K)+CI(J,K,L,M)
      SFV(J,L)=SFV(J,L)+S(J,K,L,M)
      SQFV(J,L)=SQFV(J,L)+SQ(J,K,L,M)
      CFV(J,L)=CFV(J,L)+CI(J,K,L,M)
      SSV(J,M)=SSV(J,M)+S(J,K,L,M)
      SQSV(J,M)=SQSV(J,M)+SQ(J,K,L,M)
      CSV(J,M)=CSV(J,M)+CI(J,K,L,M)
      SD8(K)=SD8(K)+S(J,K,L,M)
      SF8(L)=SF8(L)+S(J,K,L,M)
      SS8(M)=SS8(M)+S(J,K,L,M)
      IF(J.GT.7) GO TO 3
      SD6(K)=SD6(K)+S(J,K,L,M)
      SF6(L)=SF6(L)+S(J,K,L,M)
      SS6(M)=SS6(M)+S(J,K,L,M)
    3 CONTINUE
      DO 5 J=1,8
      DO 5 K=1,7
      IF(CDV(J,K).LE.1.) GO TO 28
      VMD(J,K)=SDV(J,K)/CDV(J,K)
      VSGD(J,K)=SQRT((SQDV(J,K)-(SDV(J,K)**2./CDV(J,K)))/(CD-
                                                  V(J,K)-1.))
```

```
 8 VMD8(K)=VMD8(K)+VMD(J,K)
   SQD8(K)=SQD8(K)+(VSGD(J,K)**2)
   IF(J.GT.7) GO TO 5
   VMD6(K)=VMD6(K)+VMD(J,K)
   SQD6(K)=SQD6(K)+(VSGD(J,K)**2)
   GO TO 5
28 VMD(J,K)=0.
   VSGD(J,K)=0.
   GO TO 8
 5 CONTINUE
   DO 6 J=1,8
   DO 6 L=1,3
   IF(CFV(J,L).LE.1.) GO TO 26
   VMF(J,L)=SFV(J,L)/CFV(J,L)
   VSGF(J,L)=SQRT((SQFV(J,L)-(SFV(J,L)**2./CFV(J,L)))/(CF-
                                                V(J,L)-1.))
10 IF(CF8(L).EQ.0.) GO TO 34
   SQF8(L)=SQF8(L)+(VSGF(J,L)**2)
   VMF8(L)=VMF8(L)+VMF(J,L)
   IF(J.GT.7) GO TO 6
   IF(CF6(L).EQ.0.) GO TO 35
   VMF6(L)=VMF6(L)+VMF(J,L)
   SQF6(L)=SQF6(L)+(VSGF(J,L)**2)
   GO TO 6
26 VMF(J,L)=0.
   VSGF(J,L)=0.
   GO TO 10
34 VMF8(L)=0.
35 VMF6(L)=0.
 6 CONTINUE
   DO 7 J=1,8
   DO 7 M=1,3
   IF(CSV(J,M).LE.1.) GO TO 27
   VMS(J,M)=SSV(J,M)/CSV(J,M)
   VSGS(J,M)=SQRT((SQSV(J,M)-(SSV(J,M)**2./CSV(J,M)))/(CS-
                                                V(J,M)-1.))
12 IF(CS8(M).EQ.0.) GO TO 38
   VMS8(M)=VMS8(M)+VMS(J,M)
   SQS8(M)=SQS8(M)+(VSGS (J,M)**2)
   IF(CS6(M).EQ.0.) GO TO 39
   IF(J.GT.7) GO TO 7
   VMS6(M)=VMS6(M)+VMS(J,M)
   SQS6(M)=SQS6(M)+(VSGS (J,M)**2)
   GO TO 7
27 VMS(J,M)=0.
   VSGS(J,M)=0.
   GO TO 12
38 VMS8(M)=0.
39 VMS6(M)=0.
 7 CONTINUE
```

```
      DO 31 K=1,7
      VSGD8(K)=SQRT(SQD8(K))
   31 VSGD6(K)=SQRT(SQD6(K))
      DO 32 L=1,3
      IF(CF8(L).EQ.0.) GO TO 40
      VSGF8(L)=SQRT(SQF8(L))
      VSGF6(L)=SQRT(SQF6(L))
      GO TO 32
   40 VSGF8(L)=0.
      VSGF6(L)=0.
   32 CONTINUE
      DO 33 M=1,3
      IF(CS8(M).EQ.0.) GO TO 41
      VSGS8(M)=SQRT(SQS8(M))
      VSGS6(M)=SQRT(SQS6(M))
      GO TO 33
   41 VSGS8(M)=0.
      VSGS6(M)=0.
   33 CONTINUE
      DO 15 I=1,8
      DO 14 J=1,7
      Q(I)=Q(I)+VMD(I,J)
      R(I)=R(I)+VSGD(I,J)**2.
   14 CONTINUE
      MEAN(I)=Q(I)/7.
      SIGMA(I)= SQRT(R(I))
   15 CONTINUE
      DO 42 I=3,49,2
   42 IT(I)=((I-1)/2)*100
      DO 43 I=2,48,2
      N=I-1
   43 IT(I)=IT(N)+30
C
      REWIND 1
C
   23 READ(NN,100) DAY,SHIFT,(V(J),J=1, 8),FORM
      DO 20 I=1,8
      DO 22 J=1,51
      IF(V(I).EQ.0.) GO TO 20
      IF(J.EQ.51) GO TO 21
   49 T(I,J)=((MEAN(I)+1.96*SIGMA(I))/50.)*(J-1)
      K=J+1
      T(I,K)=((MEAN(I)+1.96*SIGMA(I))/50.)*J
      IF(V(I).GT.T(I,J).AND.V(I).LE.T(I,K)) GO TO 21
      GO TO 22
   21 CT(I,J)=CT(I,J)+1
   22 CONTINUE
   20 CONTINUE
      DO 44 I=1,48
      IF(I.EQ.48) GO TO 45
```

```
      N=I+1
      IF(TIME.GE.IT(I).AND.TIME.LT.IT(N))GO TO 45
      GO TO 44
   45 IC(I)=IC(I)+1
      GO TO 46
   44 CONTINUE
   46 IF(DAY.NE.0) GO TO 23
C
C
      WRITE(IN,52)
      WRITE(IN,1103)
      WRITE(IN,1104)
      WRITE(IN,1105)
      WRITE(IN,1106)
      WRITE(IN,1107)
      WRITE(IN,1108)
      WRITE(IN,1109)
      WRITE(IN,1110)
      WRITE(IN, 200)
      WRITE(IN,1113)
      WRITE(IN, 301)((CDV(I,J),I=1,8 ),J=1,7)
      WRITE(IN,1114)
      WRITE(IN, 300)((VMD(I,J),I=1,8 ),J=1,7)
      WRITE(IN,1115)
      WRITE(IN, 300)((VSGD(I,J),I=1,8 ),J=1,7)
      WRITE(IN, 400)
      WRITE(IN, 500)(VMD8(I),VSGD8(I),CD8(I),I=1,7)
      WRITE(IN, 600)
      WRITE(IN, 500)(VMD6(I),VSGD6(I),CD6(I),I=1,7)
      WRITE(IN,1600)
      WRITE(IN,1113)
      WRITE(IN, 701)((CFV(I,J),I=1,8 ),J=2,3)
      WRITE(IN,1114)
      WRITE(IN, 700)((VMF(I,J),I=1,8 ),J=2,3)
      WRITE(IN,1115)
      WRITE(IN, 700)((VSGF(I,J),I=1,8 ),J=2,3)
      WRITE(IN,1000)
      WRITE(IN, 900)(VMF8(I),VSGF8(I),CF8(I),I=2,3)
      WRITE(IN,1001)
      WRITE(IN, 900)(VMF6(I),VSGF6(I),CF6(I),I=2,3)
      WRITE(IN,1100)
      WRITE(IN,1113)
      WRITE(IN, 701)((CSV(I,J),I=1,8 ),J=1,3)
      WRITE(IN,1114)
      WRITE(IN, 700)((VMS(I,J),I=1,8 ),J=1,3)
      WRITE(IN,1115)
      WRITE(IN, 700)((VSGS(I,J),I=1,8 ),J=1,3)
      WRITE(IN,1101)
      WRITE(IN, 900)(VMS8(I),VSGS8(I),CS8(I),I=1,3)
      WRITE(IN,1102)
```

```
WRITE(IN, 900)(VMS6(I),VSGS6(I),CS6(I),I=1,3)
WRITE(IN,1400)(MEAN(I),I=1,4),(SIGMA(I),I=1,4)
WRITE(IN,1300)((T(I,J),CT(I,J),I=1,4),J=1,51)
WRITE(IN,1400)(MEAN(I),I=5,8),(SIGMA(I),I=5,8)
WRITE(IN,1300)((T(I,J),CT(I,J),I=5,8 ),J=1,51)
WRITE(IN,1201)(IT(I),IC(I),I=1,48)
STOP
END
```

DATA REDUCTION FOR THE COMMAND/CONTROL SIMULATION
OF THE ORLANDO POLICE DEPARTMENT
BY GERALD LOCASALE

VARIABLE D1 = THIS VARIABLE IS THE TOTAL TIME TO ANSWER THE TELEPHONE

VARIABLE ANFO = THIS VARIABLE IS THE TOTAL TIME TO GATHER ALL THE INFORMATION FROM THE TELEPHACNE CALL

VARIABLE F1 = THIS VARIABLE IS THE TOTAL TIME TO CHOOSE AND THEN COMPLETE THE APPROPRIATE FORM

VARIABLE RAD = THIS VARIABLE IS THE TOTAL TIME FOR THAT FORM TO GET TO THE RADIO-OPERATOR

VARIABLE D2 = THIS VARIABLE IS THE TOTAL TIME FOR THE RADIO-OPERATOR TO READ AND ASSIGN A UNIT

VARIABLE CALU = THIS VARIABLE IS THE TOTAL TIME FOR THE RADIO-OPERATOR TO GIVE THE INFORMATION TO THE UNIT

VARIABLE TRVL = THIS VARIABLE IS THE TOTAL TIME FOR THE UNIT TO GET TO THE ASSIGNED LOCATION

VARIABLE ANV1 = THIS VARIABLE IS TOTAL INVESTIGATION TIME FOR THAT CALL

MEAN AND STANDARD DEVIATION BY DAY

THE TOTAL NUMBER PER CATEGORY

893.	885.	206.	198.	188.	164.	161.	110.
1507.	1497.	300.	287.	270.	238.	220.	118.
1513.	1496.	265.	248.	239.	218.	199.	100.
1297.	1284.	242.	229.	216.	190.	182.	92.
1333.	1316.	229.	220.	215.	198.	180.	77.
1210.	1225.	212.	205.	190.	179.	163.	74.
923.	910.	183.	184.	175.	167.	153.	88.

THE MEAN FOR EACH ELEMENT IS AS FOLLOWS

0.047	0.924	0.945	0.373	0.822	0.392	4.535	14.851
0.046	0.913	0.894	0.459	0.649	0.432	4.943	17.244
0.053	0.911	0.900	0.597	0.872	0.402	4.800	13.948
0.052	0.864	0.825	0.504	0.709	0.416	4.602	17.357
0.086	0.914	0.985	0.328	0.764	0.466	4.785	15.580
0.054	0.997	1.112	0.380	0.574	0.372	4.146	15.307
0.051	1.094	1.020	0.421	1.010	0.496	4.421	17.524

THE STANDARD DEVIATION OF EACH ELEMENT IS

0.039	0.935	1.118	0.511	1.532	0.457	3.588	17.146
0.031	1.038	0.797	0.679	0.908	0.600	3.525	16.568
0.110	1.007	1.941	0.772	1.402	0.428	3.349	11.533
0.050	0.964	0.880	0.631	1.120	0.421	3.219	15.240
0.094	1.084	0.724	0.496	1.054	0.590	3.509	18.199
0.063	1.037	0.885	0.563	0.755	0.514	2.905	18.358
0.048	1.291	1.093	0.562	2.033	0.806	3.175	16.198

MEAN AND STANDARD DEVIATION FOR A UNIT TO CLEAR THAT CALL TIME TO 10-8

22.890	17.658	896.000
25.582	17.038	1507.000
22.483	12.320	1515.000
25.329	15.689	1301.000
23.908	18.665	1333.000
22.943	18.667	1233.000
26.036	16.776	924.000

MEAN AND STANDARD DEVIATION OF TIME FOR UNIT TO GET TO SCENE

8.039	4.221	896.000
8.338	3.973	1507.000
8.535	4.330	1515.000
7.972	3.729	1301.000
8.328	4.146	1333.000
7.635	3.384	1233.000
8.513	4.364	924.000

MEAN AND STANDARD DEVIATION OF EACH VARIABLE BY SHIFT

THE TOTAL NUMBER PER CATEGORY

1993.	1973.	353.	341.	321.	316.	288.	174.
3177.	3145.	652.	618.	588.	504.	478.	207.
3506.	3495.	632.	612.	584.	534.	492.	278.

THE MEAN FOR EACH ELEMENT IS AS FOLLOWS

0.077	0.945	1.105	0.524	0.830	0.413	3.993	13.958
0.050	0.859	0.891	0.379	0.657	0.421	4.984	18.506
0.049	1.004	0.915	0.464	0.837	0.436	4.658	15.378

THE STANDARD DEVIATION OF EACH ELEMENT IS

0.094	1.121	0.988	0.749	1.399	0.451	2.883	15.958
0.061	0.954	1.379	0.523	1.313	0.675	3.512	18.606
0.043	1.088	0.933	0.633	1.200	0.484	3.381	14.057

MEAN AND STANDARD DEVIATION BY SHIFT
TIME TO 10-8

21.845	16.398	1995.
26.747	19.073	3181.
23.741	14.634	3533.

MEAN AND STANDARD DEVIATION BY SHIFT
TIME TO 10-6

7.888	3.775	1995.
8.241	4.195	3181.
8.363	4.070	3533.

MEAN AND STANDARD DEVIATION OF EACH VARIABLE BY TYPE OF FORM COMPLETED

THE TOTAL NUMBER PER CATEGORY

239.	235.	180.	177.	161.	36.	72.	10.
1540.	1531.	1388.	1344.	1290.	1277.	1154.	624.

THE MEAN FOR EACH ELEMENT IS AS FOLLOWS

0.048	0.731	0.571	0.333	0.676	0.366	1.252	18.557
0.054	1.014	0.996	0.454	0.768	0.430	4.843	15.923

THE STANDARD DEVIATION OF EACH ELEMENT IS

0.051	0.744	0.602	0.435	1.325	0.251	2.461	29.041
0.114	0.786	1.197	0.643	1.278	0.568	3.290	16.021

MEAN AND STANDARD DEVIATION BY TYPE OF FORM
TIME TO 10-8

22.534	29.195	240.
24.483	16.671	1546.

MEAN AND STANDARD DEVIATION BY TYPE OF FORM
TIME TO 10-6

3.977	2.997	240.
8.560	4.610	1546.

FREQUENCY POLYGON

0.056		0.945		0.955		0.438	
0.120		2.796		2.989		1.611	
0.0	5475	0.0	576	0.0	316	0.0	77
0.049	2545	0.128	1095	0.136	124	0.072	606
0.098	396	0.257	1090	0.272	93	0.144	286
0.147	136	0.385	899	0.409	111	0.216	84
0.196	48	0.514	715	0.545	131	0.288	51
0.245	33	0.642	663	0.681	100	0.360	35
0.294	18	0.771	523	0.817	119	0.431	26
0.343	3	0.899	485	0.954	111	0.503	28
0.392	4	1.028	385	1.090	87	0.575	28
0.441	2	1.156	338	1.226	64	0.647	23
0.490	7	1.285	262	1.362	54	0.719	38
0.539	0	1.413	209	1.499	45	0.791	20
0.588	2	1.542	164	1.635	46	0.863	36
0.637	2	1.670	118	1.771	35	0.935	28
0.686	0	1.799	135	1.907	40	1.007	25
0.735	0	1.927	106	2.044	27	1.079	21
0.784	1	2.056	92	2.180	28	1.151	12
0.833	0	2.184	89	2.316	14	1.223	11
0.882	0	2.313	76	2.452	17	1.294	8
0.931	0	2.441	52	2.589	14	1.366	12
0.980	0	2.570	66	2.725	8	1.438	10
1.029	0	2.698	44	2.861	8	1.510	12
1.078	1	2.827	41	2.997	11	1.582	11
1.127	1	2.955	48	3.134	3	1.654	12
1.176	0	3.084	34	3.270	1	1.726	7
1.225	0	3.212	28	3.406	4	1.798	5
1.274	0	3.341	22	3.542	2	1.870	7
1.323	0	3.469	29	3.679	0	1.942	1
1.372	0	3.598	20	3.815	1	2.014	3
1.421	0	3.726	18	3.951	2	2.085	4
1.470	0	3.855	12	4.087	3	2.157	6
1.519	0	3.983	18	4.224	2	2.229	5
1.567	0	4.112	12	4.360	3	2.301	2
1.616	0	4.240	13	4.496	1	2.373	3
1.665	0	4.369	11	4.632	2	2.445	3
1.714	0	4.497	5	4.768	1	2.517	1
1.763	0	4.626	11	4.905	2	2.589	2
1.812	0	4.754	7	5.041	0	2.661	2
1.861	0	4.883	9	5.177	2	2.733	2
1.910	0	5.011	5	5.313	1	2.805	2
1.959	0	5.140	5	5.450	1	2.876	1
2.008	0	5.268	9	5.586	0	2.948	2
2.057	0	5.397	8	5.722	0	3.020	0
2.106	0	5.525	1	5.858	0	3.092	0
2.155	0	5.654	1	5.995	0	3.164	2
2.204	0	5.782	2	6.131	0	3.236	2
2.253	0	5.911	7	6.267	0	3.308	1
2.302	1	6.039	6	6.403	0	3.380	0
2.351	0	6.168	4	6.540	0	3.452	0
2.400	0	6.296	7	6.676	0	3.524	1
2.449	8677	6.425	8614	6.812	1638	3.596	1571

FREQUENCY POLYGON

0.772		0.425		4.605		15.973	
3.494		1.480		8.815		43.178	
0.0	187	0.0	49	0.0	106	0.0	40
0.152	419	0.067	80	0.438	48	2.012	84
0.305	255	0.133	170	0.875	51	4.024	77
0.457	170	0.200	279	1.313	49	6.036	72
0.610	95	0.266	226	1.751	55	8.048	54
0.762	71	0.333	146	2.188	85	10.060	44
0.914	43	0.399	95	2.626	76	12.072	35
1.067	38	0.466	69	3.064	72	14.084	32
1.219	34	0.532	37	3.501	56	16.096	26
1.372	27	0.599	31	3.939	77	18.108	20
1.524	15	0.665	32	4.376	77	20.120	27
1.676	23	0.732	21	4.814	54	22.132	16
1.829	14	0.798	22	5.252	47	24.144	11
1.981	12	0.865	8	5.689	55	26.156	11
2.134	3	0.931	6	6.127	46	28.168	18
2.286	7	0.998	13	6.565	31	30.181	9
2.438	4	1.064	2	7.002	35	32.193	11
2.591	5	1.131	5	7.440	36	34.205	9
2.743	7	1.197	7	7.878	28	36.217	10
2.896	1	1.264	7	8.315	13	38.229	5
3.048	4	1.331	4	8.753	21	40.241	5
3.200	1	1.397	4	9.191	32	42.253	3
3.353	6	1.464	5	9.628	13	44.265	2
3.505	2	1.530	0	10.066	24	46.277	0
3.658	3	1.597	3	10.504	12	48.289	6
3.810	0	1.663	3	10.941	12	50.301	6
3.962	2	1.730	0	11.379	8	52.313	2
4.115	0	1.796	0	11.817	7	54.325	3
4.267	4	1.863	2	12.254	4	56.337	3
4.420	3	1.929	0	12.692	3	58.349	4
4.572	2	1.996	2	13.129	4	60.361	3
4.724	2	2.062	1	13.567	4	62.373	0
4.877	1	2.129	3	14.005	2	64.385	0
5.029	5	2.195	1	14.442	4	66.397	0
5.182	2	2.262	0	14.880	2	68.409	0
5.334	1	2.328	1	15.318	1	70.421	1
5.487	1	2.395	1	15.755	1	72.433	0
5.639	1	2.461	2	16.193	1	74.445	1
5.791	0	2.528	0	16.631	3	76.457	1
5.944	0	2.594	1	17.068	1	78.469	2
6.096	3	2.661	0	17.506	0	80.481	0
6.249	4	2.728	0	17.944	1	82.493	0
6.401	0	2.794	0	18.381	0	84.505	0
6.553	0	2.861	1	18.819	0	86.517	0
6.706	2	2.927	0	19.257	0	88.530	0
6.858	0	2.994	1	19.694	0	90.542	0
7.011	1	3.060	1	20.132	0	92.554	0
7.163	3	3.127	0	20.569	1	94.566	1
7.315	0	3.193	1	21.007	0	96.578	1
7.468	0	3.260	2	21.445	0	98.590	4
7.620	1493	3.326	1354	21.882	1258	100.602	659

0	179
30	150
100	141
130	154
200	124
230	108
300	81
330	84
400	82
430	81
500	63
530	94
600	71
630	78
700	185
730	192
800	221
830	255
900	204
930	192
1000	235
1030	255
1100	181
1130	196
1200	153
1230	158
1300	200
1330	195
1400	219
1430	167
1500	286
1530	322
1600	263
1630	222
1700	231
1730	200
1800	220
1830	188
1900	239
1930	204
2000	195
2030	212
2100	203
2130	219
2200	204
2230	120
2300	246
2330	258
2400	0

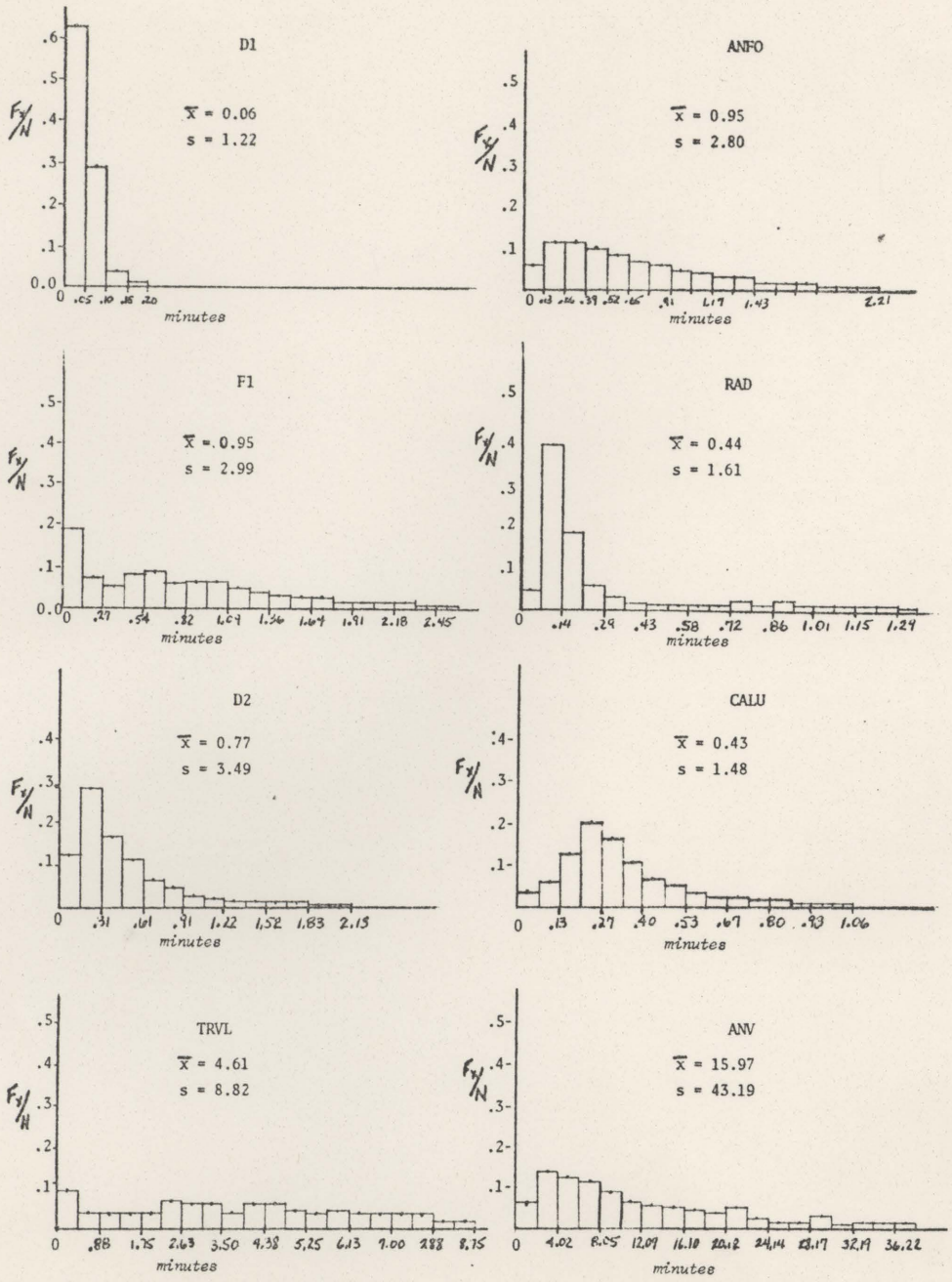


Fig. 9.--Distribution Histogram for each simulation parameter with the independent variable TIME measured in minutes on the horizontal axis and the normalized frequency within each time interval denoted F_x/N on the vertical axis.

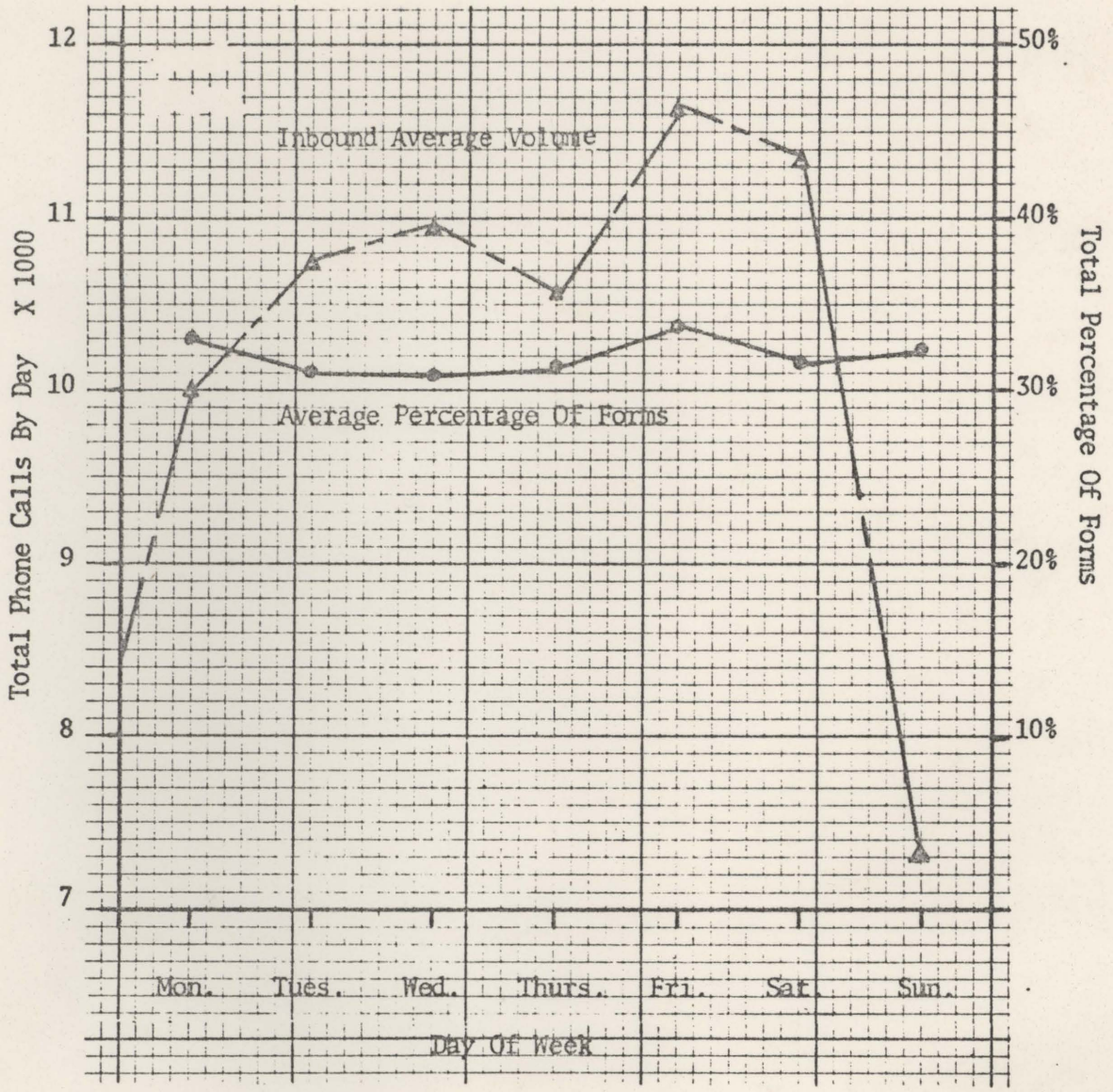


Fig. 10.--Graphical Representation of the total volume of inbound calls and percentage of all forms completed by day of week.

LIST OF REFERENCES

Pfaff, M. and Pfaff, A. "Statistical Analysis of Simulations of Human Systems," Proceedings of the Eighth Symposium of the National Gaming Council, Excelsior Springs, Missouri, June 22-24, 1969.

Dutton, J. and Starbuck, W. "Computer Simulation Models of Human Behavior: A History of an Intellectual Technology," IEEE Transactions on Systems, Man, and Cybernetics, Vol. SMC-1, No. 2, April 1971.

Fabrycky, W. and Torgersen, P. Operations Economy, Industrial Applications of Operations Research, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1966.

Chou, Y. Statistical Analysis with Business and Economic Applications, New York, Holt, Rinehart and Winston, Inc., 1969.

Maynard, H., Editor-in-Chief. Industrial Engineering Handbook, 2nd Edition, New York, Hill Book Company, Inc., 1963.

Miller, I. and Freund, J. Probability and Statistics for Engineers, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1965.

Mood, A. Introduction to the Theory of Statistics, New York, McGraw-Hill Book Company, Inc., 1950.